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ABSTRACT

This is one of several teacher's guides for the 4M Company, a set of materials for teaching metric concepts and computation skills to elementary school students. Included in the guide are sections on needed materials, metric symbols, length, perimeter, area, volume, capacity, mass (weight), decimals, conversion between metric units, temperature, and a minicourse on metrics. Answers to the activities in the related student activity manual are included. (RH)

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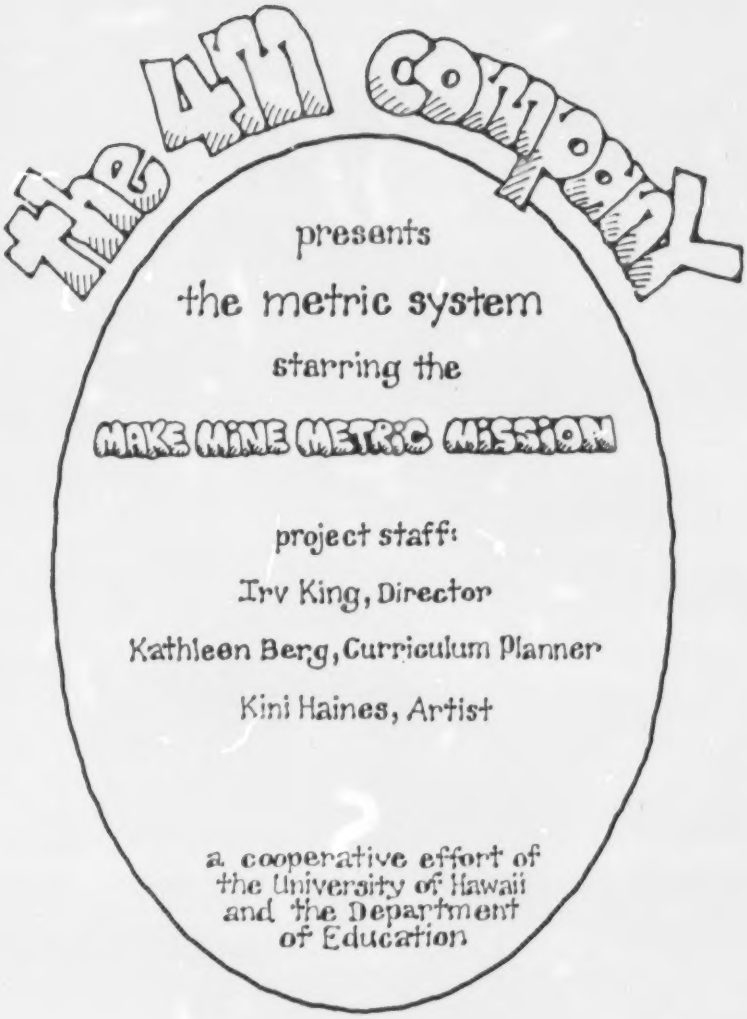

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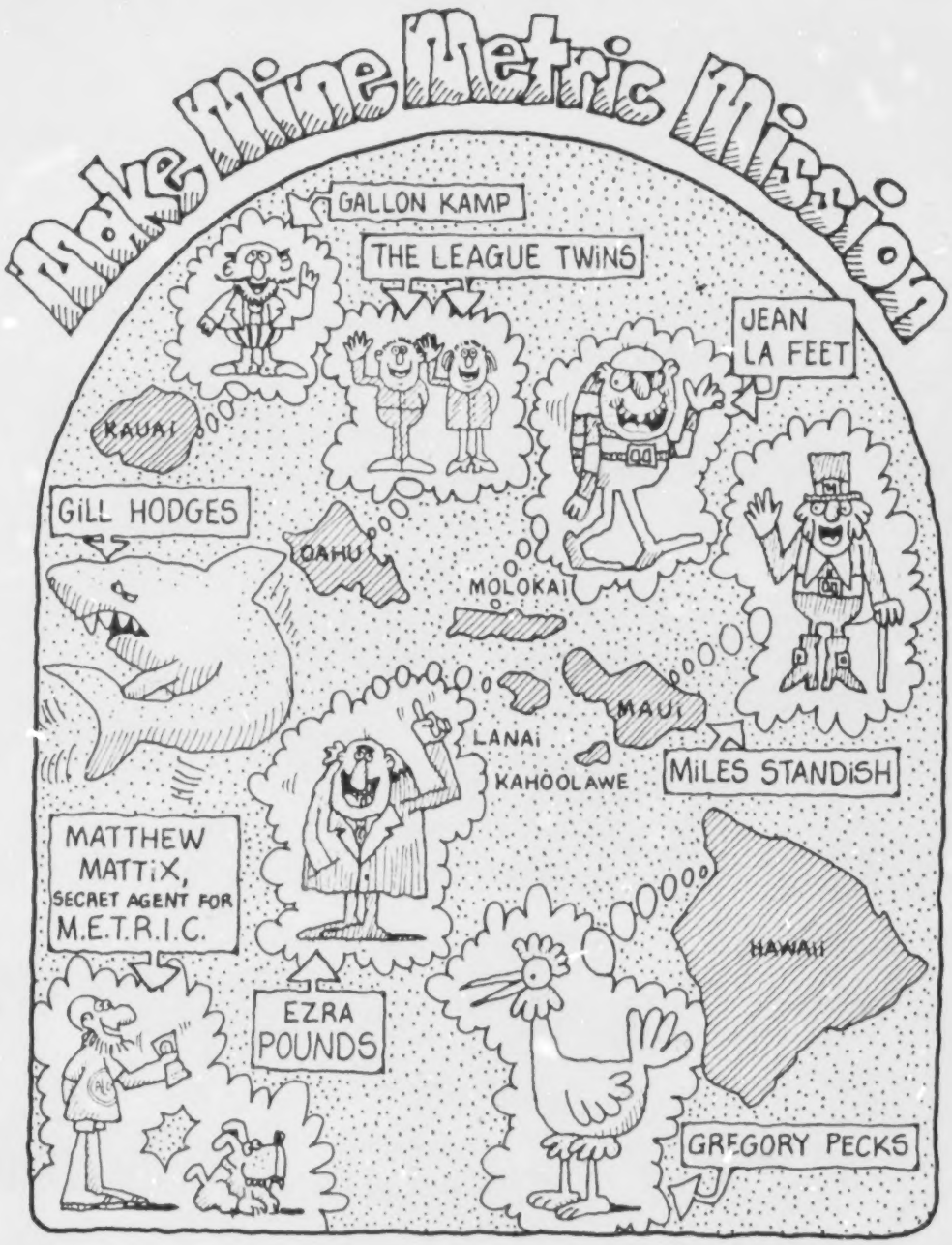
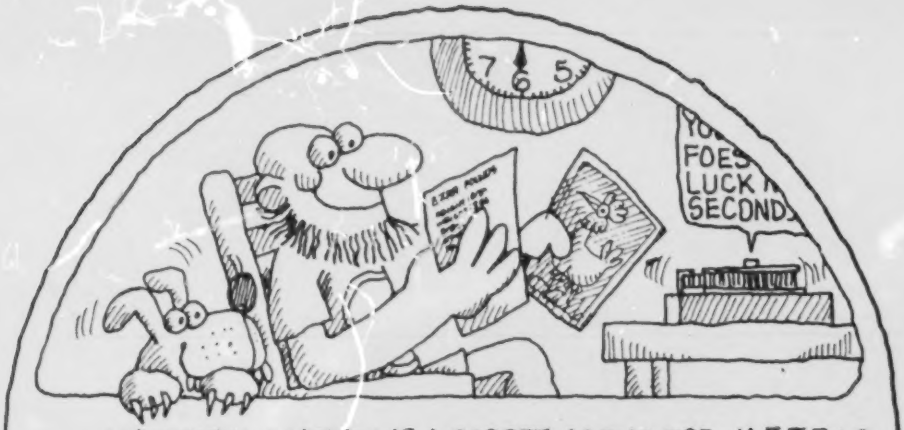
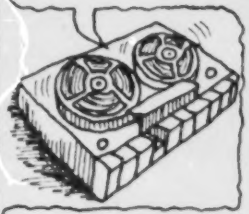

Make mine Metric Mission
GALLON KAMP
THE LEAGUE TWINS
JEAN LA FEET
KAUAI
GILL HODGES
OAHU
MOLOKAI
MAUI
LANAI
KAHOOLAWE
MILES STANDISH
MATTHEW MATTIX, SECRET AGENT FOR M.E.T.R.I.C.
EZRA POUNDS
HAWAII
GREGORY PECKS



MATTHEW MATTIX IS A SECRET AGENT FOR M.E.T.R.I.C. (MEASUREMENT EDUCATION TRAINING AND RESEARCH INVESTIGATION COMMITTEE). A SECRET PACKAGE ARRIVES AT HIS HOUSE. IT CONTAINS A TAPE RECORDED MESSAGE AND PHOTOGRAPHS. MATTHEW STARTS THE TAPE:

THE METRIC SYSTEM IS THE BEST MEASUREMENT SYSTEM IN THE WORLD. YET ITS PROGRESS IS BEING BLOCKED BY UNITS FROM THE OLD-FASHIONED ENGLISH SYSTEM. MILES STANDISH IS FIGHTING THE KILOMETER. JEAN LA FEET IS AGAINST THE METER. THE TWINS, AMERICAN AND NATIONAL LEAGUE ARE GANGING UP AGAINST BOTH THE METER AND THE KILOMETER. EZRA POUNDS ATTACKS THE USE OF THE KILOGRAM, AND GALLON KAMP OPPOSES THE LITER. BUT THE MOST DANGEROUS ENGLISH UNITS WHICH THREATEN M.E.T.R.I.C. ARE A VICIOUS SHARK GILL HODGES AND THE REBEL ROOSTER GREGORY PECKS.



YOUR MISSION SHOULD YOU DECIDE TO ACCEPT IT, IS TO CAPTURE OR CURE THESE FOES OF M.E.T.R.I.C. THEY WERE LAST SEEN IN HAWAii. GOOD LUCK MATTHEW. THIS TAPE WILL SELF-DESTRUCT IN FIVE SECONDS.

WITH HIS TRUSTY DOG AT HIS SIDE, MATTHEW MATTIX SETS OUT TO ACCOMPLISH HIS MISSION.

the 4th company

the 4M company

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to the teacher

Curriculum materials are only one of the factors involved in the learning process. No program can anticipate the other factors - your unique characteristics as a teacher, the characteristics of your students, and your classroom situation. Yet these factors must all be considered for a successful learning experience. It is you, the teacher, who must analyze these factors to make decisions and adjustments in the learning activities as described in this Teacher's Guide.

The 4M COMPANY provides a variety of classroom organizations: at times students will work as an entire class, at times they will work in small groups, and at times they will work alone. Depending on the unique combination of factors which make up your classroom, the procedures recommended in this Teacher's Guide may or may not work in your particular classroom. Feel free to adapt the program to meet your particular needs. Following the Teacher's Guide word-for-word is not important; learning the objectives of the program is!

You are a unique person, and no one will teach The 4M COMPANY exactly as you do. Your strengths, your weaknesses, your abilities, and your overall philosophy will influence your teaching. Keep in mind, however, the following roles which you must play as a teacher.

The role of a planner. The 4M COMPANY is an activity program, and you will be required to prepare materials for most lessons. Things will not always work out as you had planned, so be prepared to alter your plans if the need arises.

The role of a demonstrator. Although this Teacher's Guide outlines one approach to teaching the objectives of a lesson, you must decide if a given demonstration is working with your students. They are unique, and you may have to alter the demonstration to meet their level of understanding.

The role of a questioner. Instead of always giving answers, ask the children remedial questions that will clarify their thinking. Ask more difficult questions of children who need more challenge.

The role of a motivator. No student can be made to learn if he doesn't want to. The 4M COMPANY has tried to motivate children in several ways - the cartoon format of the booklets, the use of a story line for each grade level, and the use of games and activities. But in addition to our efforts, you will still need to motivate and encourage children to learn.

The role of a summarizer. At the conclusion of an activity, you encourage students to share their findings. It is important to summarize the results of each activity.

We have tried to make The 4M COMPANY an enjoyable and effective metric program. To a large extent your attitude will determine the success of the program. If you are unfamiliar with parts of the metric system, admit this to yourself and to your students. If you adopt a positive attitude of learning with your students, this will do much to create a good classroom environment. For ready reference, the Appendix to this Teacher's Guide contains a brief review of the metric system.

The following paragraphs deal specifically with this level of THE 4M COMPANY. Please read them carefully.

content

At this level of THE 4M COMPANY students briefly compare the English and metric systems of measurement. The systematic and logical relationships of the metric units are presented. In exploring the concepts of length, perimeter, area, volume, capacity, mass (weight), and temperature, students are exposed to the following metric units: the meter and its multiples and submultiples, the liter and its multiples and submultiples, the gram and its multiples and submultiples, the metric ton, mm^2, cm^2, dm^2, m^2, km^2, cm^3, dm^3, m^3, and degrees Celsius. Students review decimals and add, subtract, multiply, and divide one-, two-, and three-place decimals using metric models of length and area. Using a chart of metric prefixes, students convert measurements from one metric unit to another.

decimals

In The 4M companY the base ten nature of the metric system is used to review the concept of decimal fractions. A decimeter is 0.1 of a meter, a centimeter is 0.01 of a meter, and a millimeter is 0.001 of a meter. The concept is generalized, using place value and emphasizing numeration and reading decimal expressions.

zero

In writing decimal expressions less than 1.0, it is now recommended that a zero be placed in the ones' place. For example, 0.3 meters is recommended instead of .3 meters. This convention is practiced worldwide. The use of the zero has two main advantages: 1) If the decimal point is light, or somehow erased, it is immediately evident that the point is missing. For example, 03 means three tenths, or 0.3; 2) In teaching children it helps us distinguish the fractional parts from the whole parts. For example, in the expressions .27, some children might think that the 7 is in the ones' place and the 2 in the tens' place. By placing a zero in the ones' place this confusion might be avoided.

estimating

Throughout the program children should be encouraged to estimate before measuring. Encourage careful measuring, but explain that no measure is exact. Use the words "about" or "almost" to describe inexact measurements.

reinforcement

Experience has shown that retention of metric concepts and vocabulary will occur only if they are reinforced throughout the school year. Make a flashcard for each metric unit and another for its symbol. Use these frequently to reinforce metric vocabulary. It is also a good idea to set metric units in front of the class and have them identify the various units by name. Familiarity

with the units is a major goal of the program, and this can be achieved by frequent drill and review.

computation

At this level of THE 4M COMPANY computation with decimals is presented using a length model as the rationale for addition and subtraction and an area model for multiplication and division. It is expected that the basic operation algorithms will be taught in the regular math program. The work in this program will reinforce these skills and extend them to include operations with one-, two-, and three-place decimals, using measurement concepts as a rationale for the steps of the computational algorithms.

rounding off

Measurement provides an easy, visual model for teaching students how to round off; the measurement is rounded off to the nearest unit by merely looking at the measuring instrument. Explain that the measurement is rounded down if the fractional part is less than half a unit and rounded up if the fractional part is half a unit or more.

metric chart

It is recommended that each classroom have a chart of the metric system. Put one up early in the year and as each metric unit is introduced, point it out on the chart. Page 59 in this Teacher's Guide may be used to make a colorful poster where each unit can be highlighted with color when it is introduced. The page may be removed, used to make an overhead transparency, and the overhead projector used to enlarge the chart onto a piece of poster board where it can be traced and colored. An opaque projector may be used to accomplish the same thing using the page directly.

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materials

1	foot ruler marked in inches, centimeter ruler marked in millimeters
2	18 index cards (to make flashcards)
3	several meter sticks, centimeter rulers (one for each student), millimeter rulers (one for each student), masking tape
4	string, cm rulers, meter sticks
5	2 sheets of notebook-sized paper, cm rulers, 4 meter sticks
6	an assortment of boxes and blocks
7	wooden cubes, large and small boxes, a cubic centimeter (can be a block or made of paper), a cubic decimeter (can be made of paper), a cubic meter (make with 12 meter sticks as described in activity #3)
8	graduated cylinder, liter container, cubic decimeter that will hold water (must be rigid also so that the sides will not bulge and distort the volume), a variety of containers, 12 one-meter sticks
9	1-kilogram weight, 1-hectogram weight, 1-dekagram weight, 1-gram weight, page of the Teacher's Guide (for dg, cg, mg weights); two-pan balance; set of metric weights including 50g, 20g, 10g, 5g, 2g, 2g, 1g; a pencil and 6 or 7 other objects under 100g to weigh on the balance; metric bathroom scale; plastic cubic decimeter, 12 one-meter sticks taped to form a cubic meter (from Section 7, activity 3); Optional--100 pennies, 20 nickels, 10 dimes, 4 quarters, and a dollar bill for activity 7
10	meter stick marked in millimeters
11	(Optional) one or two square meters made of cardboard, several cardboard strips 1 dm x 1 m (models for one-tenth of a square meter), several squares 1 dm x 1 dm (models for one-hundredth of a square meter)
12	none
13	2 glasses of water, metric thermometers, ice, 1 cup of salt, pan or other container
14	none
15	final tests

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section 1 introduction to the metric system

Objectives: Explain some of the advantages of the metric system of measurement over the English system.

Materials: foot ruler marked in inches, centimeter ruler marked in millimeters

Vocabulary: meter, liter, gram, prefix, kilo-, hecto-, deka-, deci-, centi-, milli-, all prefix and unit combinations

SUGGESTED PROCEDURE AND ACTIVITIES:

1. Read the story line about the Make Mine Metric Mission.

2. Begin a discussion of page 1 by asking, "How many inches are equal to 1 foot?" "How many feet are equal to 1 yard?" etc. Then repeat with the metric units. "How many millimeters are equal to 1 centimeter?" etc.

   You might want to explain what the equations mean with actual rulers. Hold up a foot ruler and point out that there are 12 inches in a foot, hence we write 12 inches = 1 foot. Similarly, hold up a centimeter ruler marked in millimeters and point out that there are 10 millimeters in one centimeter, hence we write 10 millimeters = 1 centimeter.

   Two important features of the metric system should be emphasized. First, whereas in the English system the conversion factors are a hodge-podge of unrelated numbers (1, 2, 3, 5 1/2, 40, 8, 3, etc.) in metric each unit is ten times larger than the next smaller unit. Stress that each conversion factor is ten. Second, in the metric system you can tell by the name of the unit that you are measuring length, because each unit for length contains the word "meter". Likewise, all the units for measuring capacity contain "liter". There is no comparable relationship between unit names in the English system.

   Explain that the metric system was invented by French scientists in the 1790's because they wanted a logical system of measurement. Also point out that the entire world will soon be using the metric system. The United States in order to trade and communicate efficiently with the other countries of the world must use the metric system, too.

3. To prove the point about metric being an easier system, have the students close their booklets and take a quiz, which may be written on the board or reproduced on paper. Students are to fill in the blanks from memory. Add that the units go from smallest to largest:

☐ inches = 1 foot
☐ feet = 1 yard
☐ yards = 1 rod
☐ rods = 1 furlong
☐ furlongs = 1 mile
☐ miles = 1 league

☐ millimeters = 1 centimeter
☐ centimeters = 1 decimeter
☐ decimeters = 1 meter
☐ meters = 1 dekameter
☐ dekameters = 1 hectometer
☐ hectometers = 1 kilometer

If your students are typical, they'll do better on the metric than on the English system.

4. Page 2 summarizes the metric system. Students are not expected to learn any relationships at this point. The purpose is to give them an advance look at the terrain they will be covering. Point out the following:

   1) The meter, liter, and gram are the main units: meter for length, liter for capacity, and gram for mass (or weight). Hold up each unit.

   2) Prefixes are put in front of the words meter, liter, and gram to form other units, some larger, some smaller. "Kilo means 1000, so a kilometer is 1000 meters, a kiloliter is 1000 liters. What is a kilogram?" In a similar manner explain the meanings of the other five prefixes.

   3) Observe that all length units contain the word "meter", all capacity units the word "liter", and all weight units the word "gram".

5. Use the chart to ask questions such as, "Who can tell me the word which means 10 meters?"

THREE DAYS LATER ON MAUI
MILES STANDISH, I PRESUME?
AND WHO ARE YOU?
MAUI
MATTHEW MATTA, SECRET AGENT FOR NCPM, HAS BEEN SENT ON A MISSION IS TO CONVINCE YOU THAT METRIC IS BEST!
THAT'S IMPLAUSIBLE.

ENGLISH SYSTEM

12 inches → 1 foot
3 feet → 1 yard
5½ yards → 1 rod
40 rods → 1 furlong
8 furlongs → 1 mile
3 miles → 1 league

METRIC SYSTEM

10 millimeters → 1 centimeter
10 centimeters → 1 decimeter
10 decimeters → 1 meter
10 meters → 1 dekameter
10 dekameters → 1 hectometer
10 hectometers → 1 kilometer

1

12 INCHES = 1 FOOT
5280 FEET = 1 MILE
BUT 10 MILLIMETERS = 1 CENTIMETER AND 10 CENTIMETERS = 1 DECIMETER
BUT 8 FURLONGS = 1 MILE
10 DECIMETERS = 1 METER
GEE THAT IS NICE
YEAH EACH UNIT IS 10 TIMES LARGER THAN THE NEXT SMALLER UNIT
BUT 5½ YARDS = 1 ROD
AND 10 METERS = 1 DEKAMETER
REALLY?
YES WHY NOT ASK THESE PEOPLE WHICH IS BEST?

1000	kilometer (km)	kiloliter (kL)	kilogram (kg)
100	hectometer (hm)	hectoliter (hL)	hectogram (hg)
10	dekameter (dam)	dekaliter (daL)	dekagram (dag)
1	meter (m)	liter (L)	gram (g)
0.1	decimeter (dm)	deciliter (dL)	decigram (dg)
0.01	centimeter (cm)	centiliter (cL)	centigram (cg)
0.001	millimeter (mm)	milliliter (mL)	milligram (mg)

2

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section 2 · metric symbols

Objectives: Given a metric unit, write the corresponding symbol.

Given a metric symbol, write the corresponding unit.

(Note: Mastery is not expected until completion of the entire booklet.)

Materials: 18 index cards (to make flashcards)

Vocabulary: prefix symbols: k, h, da, d, c, m; unit symbols: m, L, g

SUGGESTED PROCEDURE AND ACTIVITIES:

1. The purpose of this lesson is to develop the use of symbols for metric units. To save having to write out each metric unit, symbols are used. Write on the board:

kilo (k)
hecto (h)
deka (da)
deci (d)
centi (c)
milli (m)

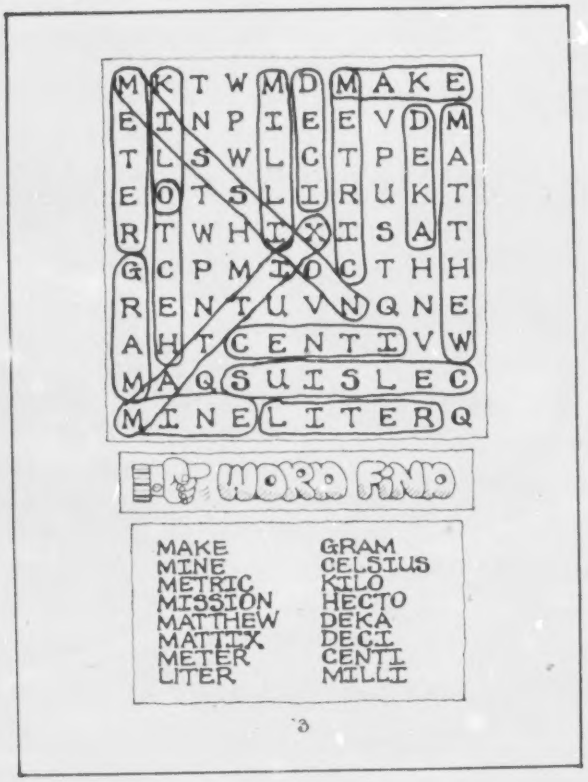
meter (m)
liter (L)
gram (g)

Thus kL means kiloliter, mg means milligram, etc.

2. On eighteen index cards, write the six prefixes, their six symbols, the three units, and their three symbols. Hold up a prefix and unit, then have a student pick up the corresponding symbol cards. As another activity, hold up a prefix and a unit, ask students to give the corresponding symbol in unison. Special distinction should be made between "da" for "deka" and "d" for "deci".

Reverse the procedure, holding up the symbols and asking for the corresponding units.

3. Page 3 contains all the metric units spelled horizontally, vertically, or diagonally. Students are to find and circle the hidden words.


M K T W M D M A K E
E I N P I E E V D M
T L S W L C T P E A
E O T S L I R U K T
R T W H I X I S A T
G C P M I O C T H H
R E N T U V N Q N E
A H T C E N T I V W
M A Q S U I S L E C
M I N E L I T E R Q
WORD FIND
MAKE
MINE
METRIC
MISSION
MATTHEW
MATTIX
METER
LITER
GRAM
CELSIUS
KILO
HECTO
DEKA
DECI
CENTI
MILLI

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section 3 · length

Objectives: Given an object and a choice of a meter, a centimeter, or a millimeter ruler, select an appropriate ruler and determine the length of the object.

Given a distance chart determine the distance in kilometers between two locations.

Materials: several meter sticks, centimeter rulers (one for each student), millimeter rulers (one for each student), masking tape

Vocabulary: meter, decimeter, centimeter, millimeter, kilometer

SUGGESTED PROCEDURE AND ACTIVITIES:

1. Hold up a meter and explain that it is the base unit of length in the metric system. Explain that its symbol is m. Then have students use meter sticks to complete page 4. They are to circle the most appropriate response to make each statement true.

2. If a yard stick is available, compare the sizes of a yard and a meter. Observe that 1 yard = 36 inches, but 1 meter is more than 39 inches.

3. Draw a line less than 1 meter long on the board. Have a student try to measure its length with a meter stick. The meter is too large a unit for measuring the line. Explain that the French scientists invented a smaller unit by dividing a meter into 10 equal parts called decimeters. "Deci" means "tenth". The symbol for decimeter is "dm", "d" for "deci", "m" for "meter". Use a decimeter to measure the line on the board. Explain that since the decimeter is not a commonly used unit, it is not necessary for the students to measure with it. Write 10 dm = 1 m on the board and verify the relationship by counting.

4. The prefix "centi" means, "hundredth". Display a centimeter ruler and point out that there are 100 cm in 1 meter. Write centimeter and its symbol "cm" on the board. Then assign pages 5 and 6.

5. Finally introduce the millimeter and its symbol "mm". A dime is about 1 mm thick. "Milli" means "thousandth", hence a millimeter is one-thousandth of a meter. Point out that 1000 mm = 1 m. Demonstrate how to measure with a millimeter ruler, pointing out that since it is a small unit, great care must be taken. Then assign page 7.

6. Cut a piece of masking tape two meters long and tape it to the floor or wall. Have a student measure it in meters,

and write "2 m" on the board. Have another student measure it in centimeters, and write "200 cm" on the board. Do the same with millimeters, writing "2000 mm" on the board. Use this to point out that the meter is the most appropriate unit to use for measuring the tape. (Note: the mm measurement is the most "precise" of the three since the mm is the smallest of the three units. It is not necessarily the most "accurate" since accuracy depends on how carefully you measure and not the unit size.)

Then measure the length of the student metric booklet in meters (too big), centimeters, and millimeters. This time the centimeter is the best unit.

Finally, try to measure the width of a nickel in meters, centimeters, and then millimeters. The millimeter is the best unit to use in this case.

Now assign the top part of page 8. Discuss the results to make certain all children understand.

7. The bottom of page 8 will serve as a check-up to see if students have mastered the objective of this lesson. Set out meter sticks, centimeter rulers, and millimeter rulers. Read the problems aloud so that each student understands the task.

8. Introduce the kilometer as the unit for measuring long distances. Write:

   1000 meters=1 kilometer

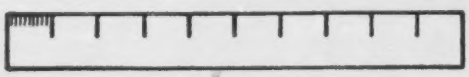
   on the board.

   It is a good idea to mark off or walk off a distance of one kilometer to give the students some idea of its length. A trundlewheel would come in handy here.

9. Page 9 contains a table which lists distances between various spots on Oahu in kilometers. Explain how to use the table (for example, by following the Honolulu Airport column down and the Waikiki row across we see that it is 14 kilometers from the Airport to Waikiki). Then ask various questions, having students record their answers on a piece of scratch paper. For example, ask, "How far is it from Ala Moana Center to Kailua?"

   Pages 10 and 11 give distances on Maui, Lanai, and Molokai. Let students take turns stating distances like "It is 72 kilometers from Halawa to Maunaloa."

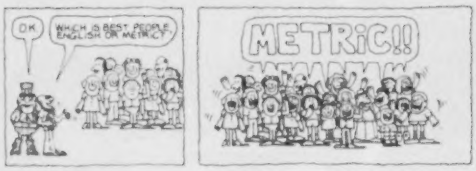
10. As a summary exercise on the metric units of length give each student a one meter long strip of adding machine tape. Have them use the decimeter strip in the back of their books to mark off the meter into ten decimeters. Then using a ruler they should mark off one decimeter into ten centimeters and one centimeter into ten millimeters.



Discuss the relationships between the units again and have students write the following at the left end of their paper meter strip:

10 millimeters=1 centimeter
10 centimeters=1 decimeter
10 decimeters=1 meter

Let them take these strips home to help explain the metric system to their parents.



Circle the best answer.

I am *more than* *about* *less than* one meter tall.	My desk is *more than* *about* *less than* one meter tall.
The door is *more than* *about* *less than* one meter wide.	The window is *more than* *about* *less than* one meter wide.

Measure to find the answer.

Our room is _____ meters long.	Our room is _____ meters wide.

4

Measure in centimeters.

A 2 cm

B 7 cm

C 10 cm

E 3 cm

D 14 cm

F 8 cm

G 11 cm

5

Use page 5 to answer these questions.

1. How long is the length of A plus the length of B? 9 cm	2. How long is the length of C plus the length of D? 24 cm
3. How long is the length of E plus the length of F plus the length of G? 22 cm	4. If you add all the lengths together (A+B+C+D+E+F), how long are they? 55 cm
5. Which is the longest stick? D	6. Which is the shortest stick? A
7. Which sticks will add up to 10 centimeters? A and F B and E	8. Measure your metric booklet: about 21 cm tall about 16 cm wide

6

*note: accept answers within a mm of those given.

Measure in millimeters. Be careful!

49 mm

100 mm

38 mm

95 mm

8 mm

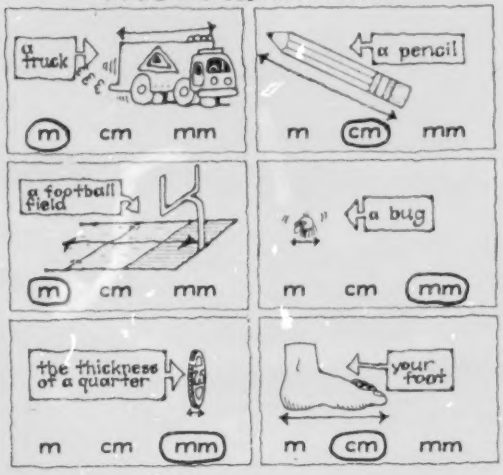
52 mm

17 mm

67 mm

7

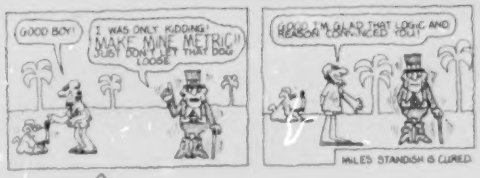
Circle the best unit to use.



Check-up time

1. Measure the width of the room. about _____
2. Measure the width of your hand. about _____
3. Measure the length of this bug. about 7mm

8


GOOD BOY!
I WAS ONLY KIDDING! MAKE MINE METRIC! JUST DON'T LET THAT DOG LOOSE
HOOO I'M GLAD THAT LOGIC AND REASON CONVINCED YOU!
MILES STANDISH IS CURED.

DISTANCES IN KILOMETERS ON OAHU

Ala Moana Center	Central Honolulu	Diamond Head	Honolulu Airport	'Kahuku	Kailua	Makaha	Pearl City	Waialua	Waikiki	Waimanalo
3										
6	10									
11	8	18								
58	54	62	54							
21	18	26	24	49						
56	53	62	49	85	64					
22	19	29	11	53	32	34				
51	48	58	40	27	61	58	29			
3	6	3	1	61	24	59	56	54		
26	22	27	29	50	8	69	37	66	29	

9

ONE WEEK LATER ON MOLOKAI...
DEAN LA FEET, I PRESUME?
AND WHO ARE YOU?
MOLOKAI
MATTHEW MATTA, SECRET AGENT FOR METRIC MY MISSION IS TO CONVINCE YOU THAT METRIC IS BEST!
THAT'S IMPOSSIBLE!

DISTANCES IN KILOMETERS ON MAUI

Haleakala Park	Hana	Kaanapali	Kahalui Airport	Kihei	Lahaina	Paia	Wailuku
94							
86	128						
42	83	46					
53	94	38	14				
80	122	6	37	32			
37	75	59	14	26	53		
46	96	40	8	14	34	19	

10

DISTANCES IN KILOMETERS ON LANAI

Kaumalapau Harbor	Lanai Airport	Lanai City	Manele Bay
5			
10	5		
22	18	13	

DISTANCES IN KILOMETERS ON MOLOKAI

Halawa	Kalaupapa Lookout	Kaunakakai	Kualapuu	Maunaloa	Molokai Airport
64					
45	16				
58	6	10			
72	29	27	22		
58	14	13	8	16	

11

13

the 4M company

section 4 · perimeter

Objectives: Given a polygon and the measures of its sides, add to determine the perimeter.

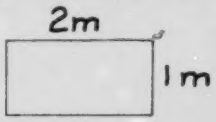
Given a polygon and a centimeter ruler, measure the sides then add to determine the perimeter.

Materials: string, cm rulers, meter sticks

Vocabulary: perimeter, rectangle

SUGGESTED PROCEDURE AND ACTIVITIES:

1. Cut a piece of string six meters long, and lay it on the floor in the shape of a 2 meter x 1 meter rectangle.



Pose a problem like the following to the class. "Suppose I want to build a fence to make a pen for my pet rabbits. How long would the fence have to be?" Elicit suggestions from the class. Then measure each side of the string rectangle, recording all four lengths on the board. Then add them up.

$$\begin{array}{r} 2\,m \\ 1\,m \\ 2\,m \\ +\,1\,m \\ \hline 6\,m \end{array}$$

"The distance around the rectangle is six meters." Straighten the piece of string out, then measure again to verify that it is six meters long. "We call the distance around a figure the perimeter."

2. Make a triangle with the same string. "What is the perimeter of this triangle?" Make other figures as well so that students can see that: 1) different shapes can have the same perimeters and; 2) the length of the string remains the same.

3. Assign page 12.

4. Using objects (chalkboard erasers are fine) to mark the vertices (corners) of a polygon, let students work in pairs to make lawn polygons with a specific perimeter. "Can you lay out a rectangle with a perimeter of 20 meters?"

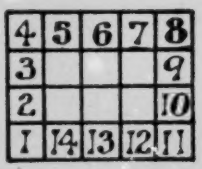
5. While some students work on exercise 4, others can be working on pages 13 and 14.

6. Pose the following question: "How

many different rectangles can you make which have a perimeter of 24 cm? Consider each side in whole cm, no halves, thirds, etc." There are six: 1 x 11, 2 x 10, 3 x 9, 4 x 8, 5 x 7, and 6 x 6.

7. Assign page 15. You may have to explain how to determine the perimeter. The following is a common mistake:

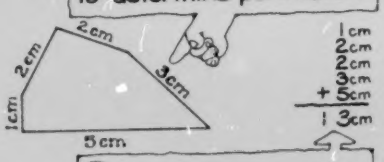
COMMON MISTAKE



Stress that the length of each side is used, thus the blocks on the corners have two sides counted. Some students may need to use a ruler. Perimeters of 2 cm and 11 cm will require fractions.

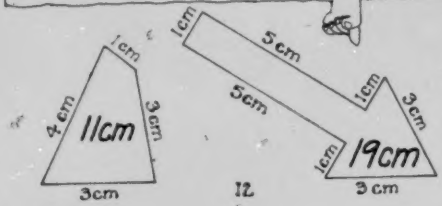
EVERYBODY HAD TO HAVE TWO FEET TO WALK ON AND A YARD TO PLAY IN.
BUT NOT TO MEASURE WITH
WHAT'S SO GOOD ABOUT METRIC?
GLAD YOU ASKED

Add lengths of all sides to determine perimeter.



So perimeter = 13 cm

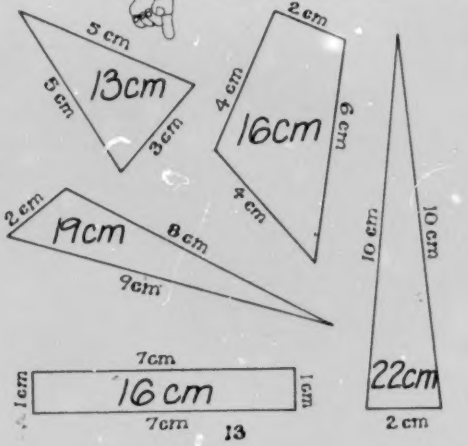
Write the perimeter inside each figure.



12

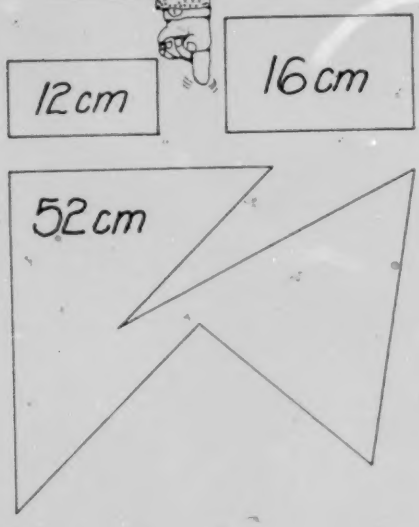
NUMBER ONE: THE METER IS THE BASIC UNIT FOR LENGTH. EVERY OTHER UNIT OF LENGTH HAS THE WORD "METER" IN IT
GIVE ME AN EXAMPLE
WELL THE KILOMETER, HECTOMETER, DEKAMETER, DECIMETER, CENTIMETER, MILLIMETER ARE ALL FOR UNITS OF LENGTH
IS THAT ALL?

Write the perimeter inside each figure.



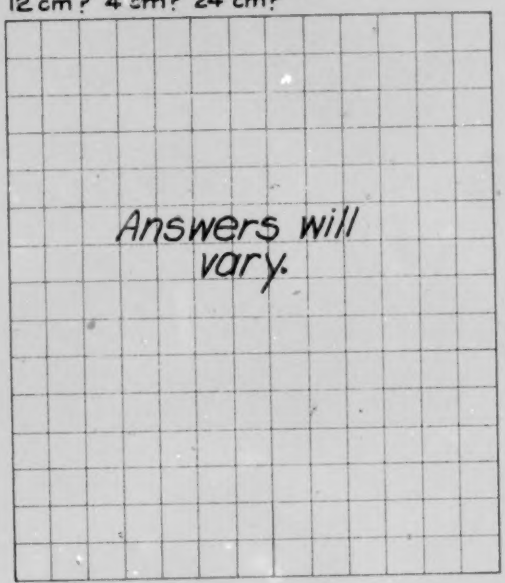
13

Find the perimeter in cm.



14

Can you draw a rectangle with perimeter 12 cm? 4 cm? 24 cm?



Special Challenge:

Can you draw a rectangle with perimeter 2 cm? 11 cm?

15

the 4M company

section 5 · area

Objectives: Given a region and a choice of the metric units km^2, m^2, and cm^2, select a unit of appropriate size for determining the area.

Given a rectangle on which square units are drawn, count the number of rows and columns, then multiply to determine the area.

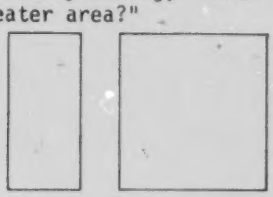
Given a rectangle and a centimeter ruler, measure the sides then multiply to determine the area.

Materials: 2 sheets of notebook-sized paper, cm rulers, 4 meter sticks

Vocabulary: area, square millimeter, mm^2, square centimeter, cm^2, square decimeter, dm^2, square meter, m^2, square kilometer, km^2, two dimensions

SUGGESTED PROCEDURE AND ACTIVITIES:

1. Explain that area tells us "how much surface". Hold up a regular sheet of notebook paper and a piece half its size, and ask, "Which piece of paper is bigger?" Explain that the question is really asking, "Which has the greater area?"



SAME LENGTH, DIFFERENT WIDTH.

Play the devil's advocate. "I think they have the same area, because, look, they have the same length!"

The students will point out that the other dimensions are different. This is important: to determine area, we need to consider <u>two</u> dimensions.

2. Page 16 illustrates three metric units of area. Explain that the amount of surface is usually given in square units. The square notation (the ^{2}) reminds us that we need to know two dimensions to determine area. Point out that a square millimeter is a square each of whose sides is a millimeter; etc.

3. Page 17 asks students to mark the rectangle, A or B, which has the greater area. The first two are easy, but the third one is not. A is taller, but B is wider. If students connect dots on opposite sides of the rectangles, they can then count the number of square centimeters in each rectangle. A has $6 \times 4 = 24\ cm^2$, whereas B has $5 \times 5 = 25\ cm^2$.

4. Point out that the area of a rectangle can be determined by multiplying length times width. On page 17, A is 6×4, B is 5×5. Hence B is larger.

5. Assign pages 18 - 21. Make up extra

worksheets if you think students need more practice.

6. Lay four meter sticks on the floor to form a square meter. The square meter is a very commonly used unit of area. As a class activity, find the area of the floor.

7. The square kilometer (km^2) is used for measuring larger areas of land. Try to think of some way to give the students an idea of a square kilometer. If a city map is available, a square kilometer could be shown in terms of streets near your school. (A kilometer is 6/10 of a mile. So a square with sides 6/10 of a mile would be a square kilometer.)

   Page 22 asks specific questions about large areas. Page 23 asks students to decide the best unit for measuring various areas. Do these pages as a class.

8. Page 24 should also be done as a group. It might be a good idea to draw each rectangle on the board.

Units of AREA

Square millimeter (mm^2)

Square centimeter (cm^2)

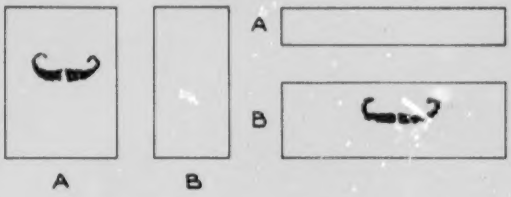
Square decimeter (dm^2)

Measure the sides of each square.

16

NUMBER TWO PREFIXES TELL US HOW LONG A UNIT IS
HOW?
A KILOMETER=1000 METERS
A HECTOMETER=100 METERS
A DECAMETER=10 METERS
A METER
A DECIMETER=0.1 METER
A CENTIMETER=0.01 METER AND
A MILLIMETER=0.001 METER
HEY! EACH UNIT IS 10 TIMES LARGER THAN THE NEXT SMALLER UNIT. THAT'S NIFTY!
THERE'S HOPE FOR YOU YET LAFFEY!

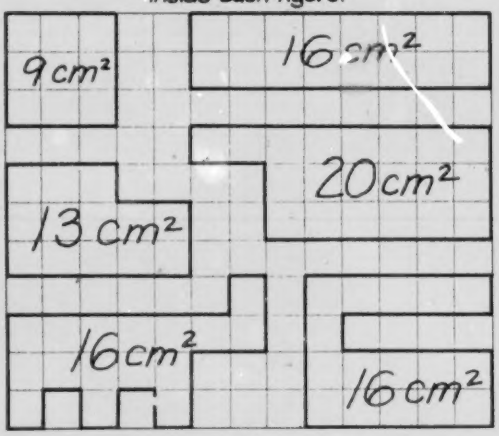
Draw a moustache on the rectangle with the larger area.



17

NAW! I CAN'T DESERT THE ENGLISH SYSTEM
BUT THE METRIC SYSTEM WAS INVENTED BY THE FRENCH IN 1795
REALLY! I'M FRENCH YA KNOW. MAYBE THE METRIC SYSTEM ISN'T SO BAD AFTER ALL
IT'S TERRIFIC!!!

Count the squares. Write the area inside each figure.



18

For rectangles only.

10 cm

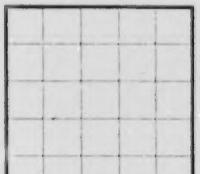
1	2	3	4	5	6	7	8	9	10
20	19	18	17	16	15	14	13	12	11

2 cm

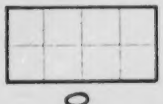
LOOK: 10 × 2 = 20

A= 12 cm^2

A= 20 cm^2



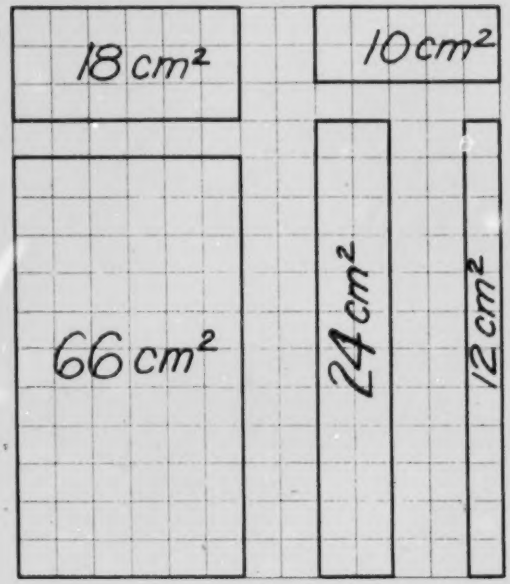
A= 25 cm^2



A= 8 cm^2

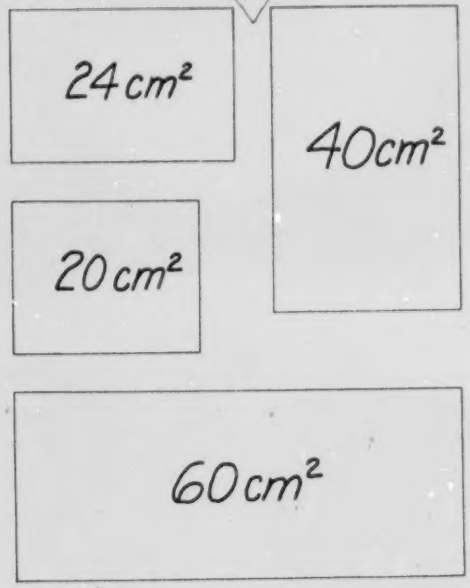
19

Find the area by multiplying.

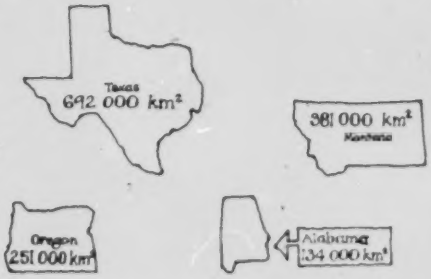


20

Use a ruler to help you find the area.



21



Which state on this page has the largest area?
Texas
...the smallest?
Alabama

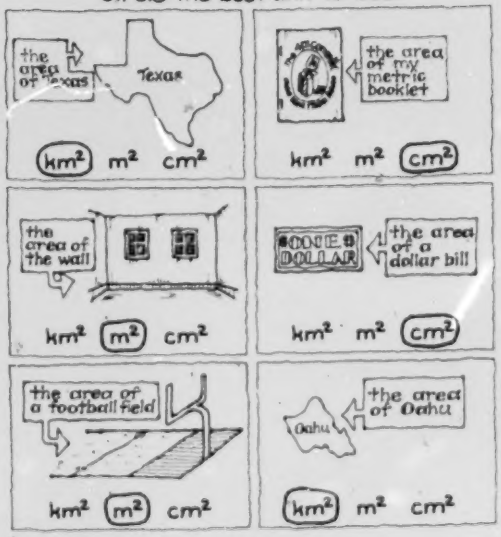
Texas is how much larger than Oregon?
441 000 km²

Would five Alabamas be larger or smaller than Texas?
smaller

What is the combined land area of all four states?
1 458 000 km²

22

Circle the best unit to use.



23

NO! METRIC IS BAD!
GRRRR
GRRRRR
ONLY KIDDING! MAKE MINE METRIC!!!
GOOD BOY, LA FEET. I KNEW LOGIC AND REASON WOULD CONVINCE YOU.
JUST KEEP THAT LOGIC AWAY FROM ME!
JEAN LA FEET IS CURED.

The data below represent rectangles.
Fill in the chart.

length	width	perimeter	area
37cm	18cm	110 cm	666cm^2
23 m	10m	66cm	230cm^2
14mm	43mm	114cm	602 cm^2
87km	15 km	204cm	1305cm^2

24

the 4M company

section 6 · three-dimensional drawing (optional)

Objectives: (Optional) Draw pictures of three-dimensional rectangular solids.

Materials: an assortment of boxes and blocks

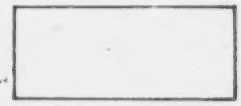
Vocabulary: three-dimensional, 3-D, two dimensional, space figures

SUGGESTED PROCEDURE AND ACTIVITIES:

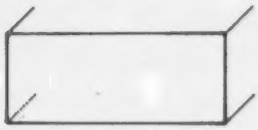
1. The purpose of this lesson is to prepare the students for the next lesson on volume. Explain that a space figure, such as a box, is three-dimensional (3-D), but that a piece of paper is two-dimensional. To draw pictures of three-dimensional objects requires some skill. At the top of page 25, three dimensions are illustrated. Point out that direction 3 gives the appearance of depth, of going away from the reader.

   Illustrate how to draw a rectangular solid on the board. There are three basic steps:

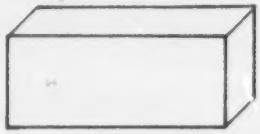
   1) Draw a rectangle;



   2) From each vertex, draw parallel line segments which are equal in length; if the line goes inside the rectangle, omit it;



   3) Connect the line segments with lines parallel to the sides of the rectangle.



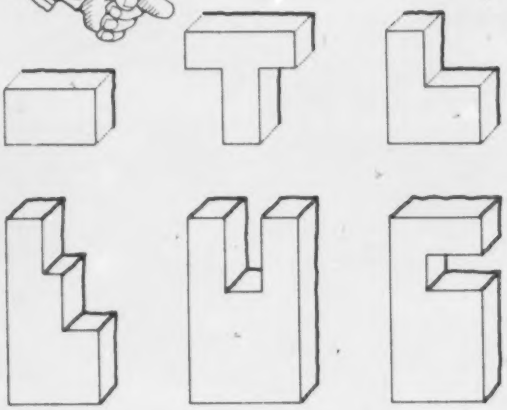
2. Have students use a straight edge to practice drawing rectangular solids.

3. Pages 25 and 26 provide practice at drawing a variety of three dimensional figures. The same three steps are involved.

4. If you have a set of blocks, make various shapes and have students practice drawing them. Let them also try to draw boxes.

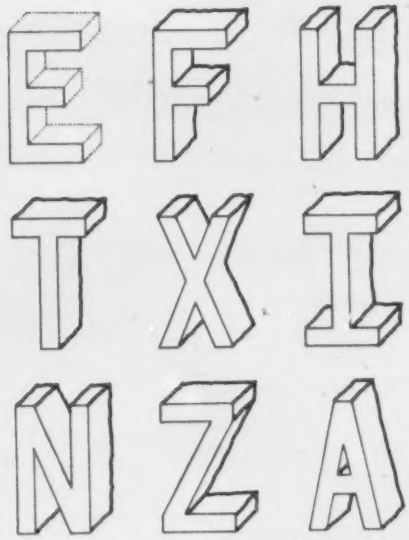
Space figures are three-dimensional. From a given point, we go in three directions.

Can you make these look like three-dimensional figures?



25

MAKE 3-D LETTERS!



26

the 4M company

section 7 · volume

Objectives: Given a rectangular solid and a choice of the metric units m^3, dm^3, and cm^3, select a unit of appropriate size for determining the volume.

Given an illustration of a rectangular solid on which cubic units are drawn, count the number of rows, columns, and layers, then multiply to determine the volume.

Given a rectangular solid and the measures of its sides, multiply to determine the volume.

Materials: wooden cubes, large and small boxes, a cubic centimeter (can be a block or made of paper), a cubic decimeter (can be made of paper), a cubic meter (make with 12 meter sticks as described in activity #3)

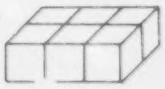
A plastic cubic decimeter box with plastic inserts showing cubic centimeters is ideal to use in Sections 7, 8, and 9. Put Scotch magic mending tape over any small holes in the box to make it watertight for use in Sections 8 and 9.

Vocabulary: volume, three dimensions, cubic centimeter, cm^3, cubic decimeter, dm^3, cubic meter, m^3

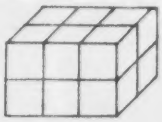
SUGGESTED PROCEDURE AND ACTIVITIES:

1. Volume is a measure of how much space a figure occupies. Hold up two boxes and ask, "Which box is bigger? By bigger I mean which box occupies the most space?" Explain that we say one box has a "bigger volume" than the other.

2. Stack wooden cubes to form rectangular solids. Lay a bottom layer first, say, 2 x 3.



"What is the volume now?" Answer; six cubes. Add another layer.

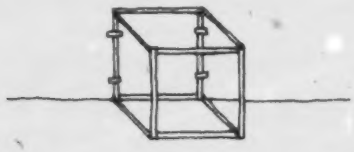


"What is the volume now?" Twelve cubes, six in each of two layers. "Note that it is two wide, three long, and two high. 2 x 3 x 2 = 12. We can find the volume of rectangular solids by multiplying its three dimensions."

Repeat with several other examples.

3. Compare the cm^3, the dm^3 and the m^3.

Explain that the 3 tells us we need three dimensions to determine volume. You should have models of a cm^3 and a dm^3. To make a model of a m^3, you will need twelve sticks one meter long. Tape them together to form a m^3. Tape it to a wall for rigidity.



4. Hold up a small box and ask, "Which unit would be best for finding the volume of this box?" Repeat with other objects. Have small objects for the cm^3, and name large objects, such as the volume of the classroom, for the m^3.

   Quiz the students to make sure they can distinguish between the three units, "Who can show me the cubic decimeter?"

5. Assign pages 27 - 30.

6. Page 31 can serve as a page for discussion.

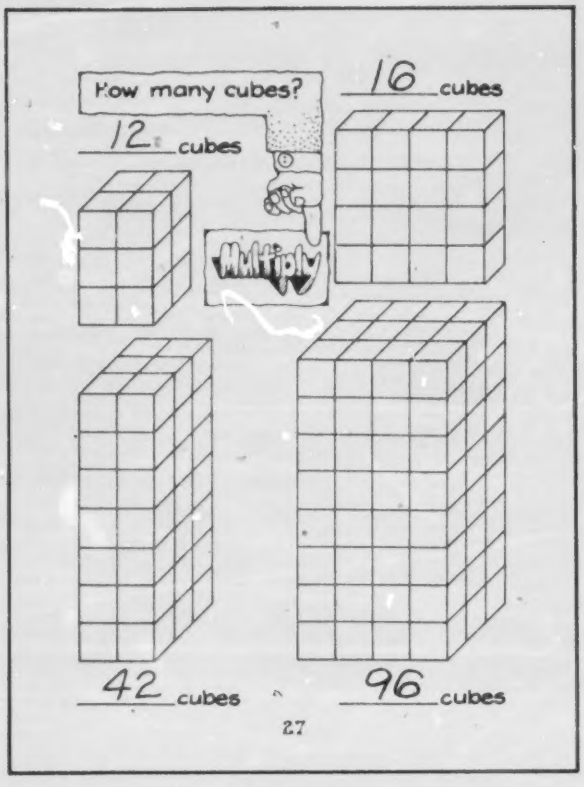
7. For your better students! Challenge them to answer the following questions:

   1) How many cm^3 would fit into a dm^3?

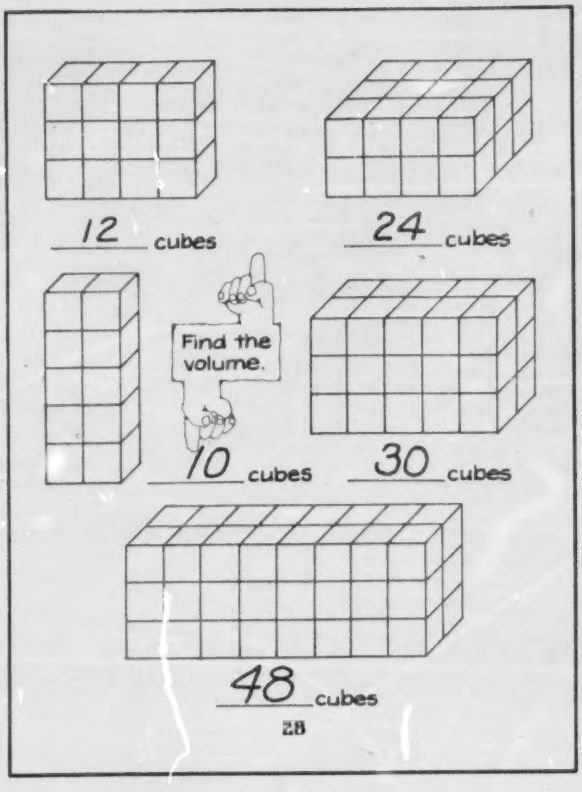
   2) How many dm^3 would fit into a m^3?

   3) How many cm^3 would fit into a m^3?

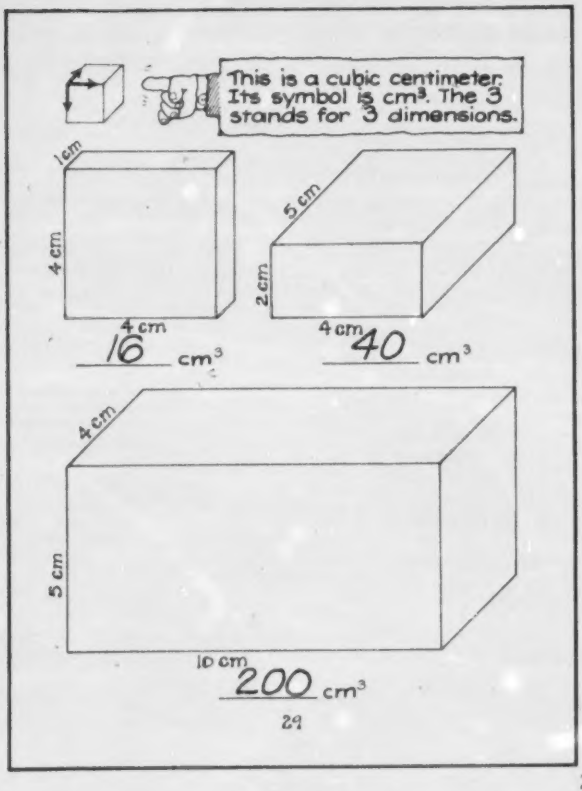
   Answers: 1) 1 000 (10 x 10 x 10); 2) 1 000 (10 x 10 x 10); and 3) 1 000 000 (100 x 100 x 100).


How many cubes?
16 cubes
12 cubes
Multiply
42 cubes
96 cubes

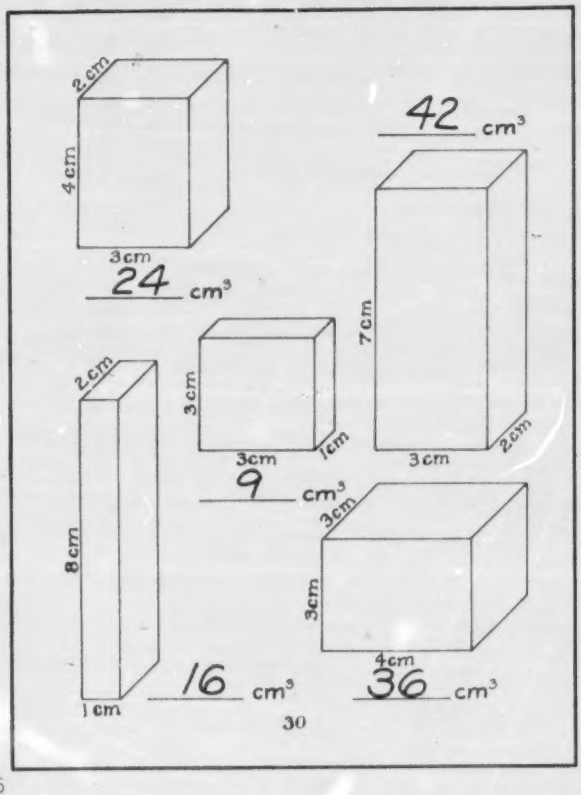
27


12 cubes
24 cubes
Find the volume.
10 cubes
30 cubes
48 cubes

28

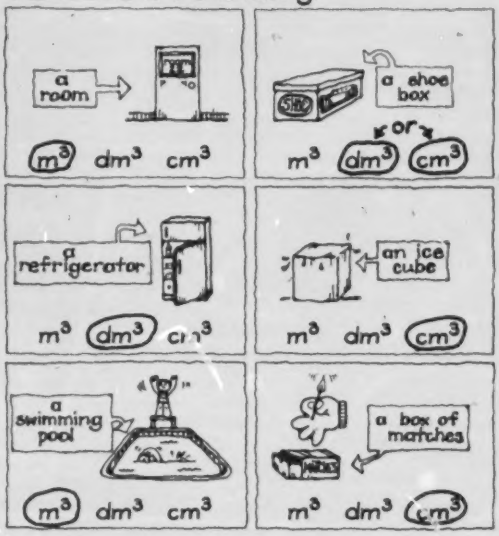

This is a cubic centimeter. Its symbol is cm³. The 3 stands for 3 dimensions.
1cm
4cm
4cm
16 cm³
5cm
2cm
4cm
40 cm³
4cm
5cm
10cm
200 cm³

29


2cm
4cm
3cm
24 cm³
42 cm³
7cm
3cm
2cm
2cm
3cm
3cm
1cm
9 cm³
8cm
1cm
16 cm³
3cm
3cm
4cm
36 cm³

30

Circle the most appropriate unit for finding the volume of the following:



31

the 4M company

section 8 · capacity

Objectives: Given a container and a choice of the metric units kiloliter, liter, and milliliter, select a unit of appropriate size for determining the capacity.

Given a container and a graduated cylinder calibrated in milliliters, determine the capacity of the container.

Materials: graduated cylinder, liter container, cubic decimeter that will hold water (must be rigid also so that the sides will not bulge and distort the volume), a variety of containers, 12 one-meter sticks

A plastic cubic decimeter box with plastic inserts showing cubic centimeters is ideal to use in Sections 7, 8, and 9. Put Scotch magic mending tape over any small holes in the box to make it watertight for use in Sections 8 and 9.

Vocabulary: capacity, liter, L, cubic decimeter, dm^3, kiloliter, kL, milliliter, mL, graduated cylinder

SUGGESTED PROCEDURE AND ACTIVITIES:

1. Introduce the liter as the base unit for measuring liquid. Set out a cubic decimeter and have a student measure its edges. Each edge is one decimeter. Then have the class guess which is larger, the cubic decimeter or the liter. Fill the cubic decimeter with water, then pour the water into the liter container. This will show that a cubic decimeter is a liter. In devising the metric system, the French scientists defined the liter to be a cubic decimeter. There is no such relationship between the foot and the quart.

   Refer to the chart on page 2 to point out that the prefixes also apply to the liter. The kiloliter (kL), liter (L), and milliliter (mL) are the only commonly used units.

2. Quiz the students on the units for capacity without referring to the chart. See if they can answer questions, such as, "What is the metric name for 1000 liters?" At the same time provide practice on spelling.

3. Have students bring labels, cartons, etc., from home which are marked in metric units. Many medicine labels will have "mL" or "ml" on them. These will make a good bulletin board display.

4. Demonstrate how to use a graduated cylinder to find the capacity of a tin can. This will be difficult for some children, depending on the gradations

on the cylinder. Explain carefully. Then assign pages 32 and 33. Correct errors.

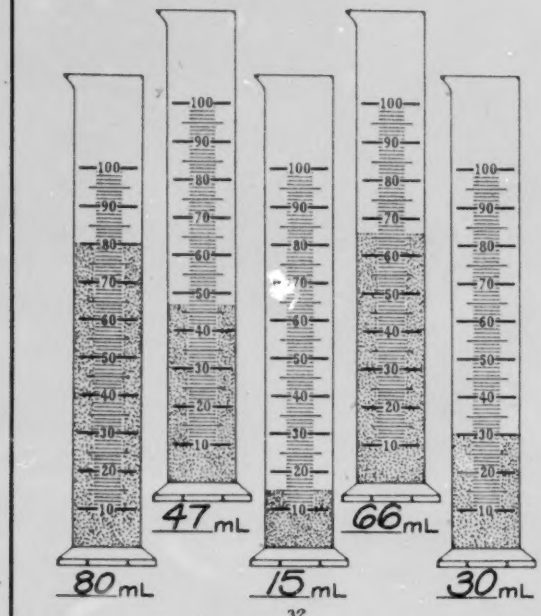
5. Mark four containers (smaller than a liter) A, B, C, and D. Set up a water station with these containers and a graduated cylinder. While others are at their desks, let pairs of students go to the station to find the capacities of the four containers. They record their findings on page 34.

6. Form a cubic meter by taping twelve one-meter sticks together. The capacity of the cubic meter is 1000 L, or a kiloliter. The kiloliter is used for large capacities, such as swimming pools, gasoline tanks, etc.

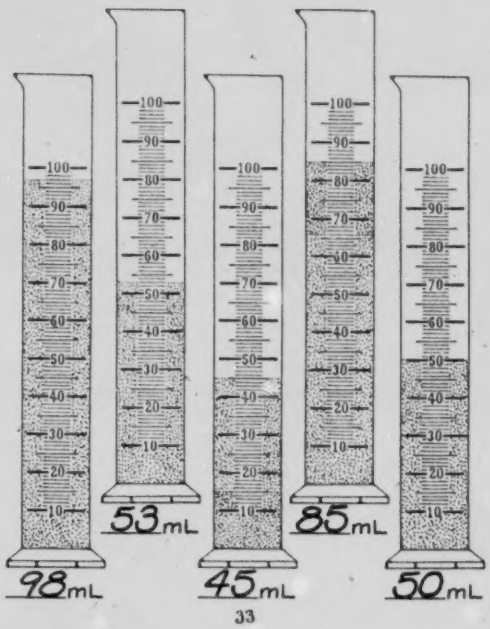
7. Assign page 35. Students are to circle the most appropriate unit for measuring the capacity of each container. Discuss each exercise.

8. Divide the class into two teams and play an estimation game. Set out two identical jars. Have one member of each team come forward. You call out an amount of water, and each student tries to pour that amount of water into his container. You then check their estimates using a graduated cylinder. Closest estimate scores one point.

9. Page 36 provides spelling practice.



32



33

TWO DAYS LATER ON OAHU
THE LEAGUE THING, I PRESUME
I'M AMERICAN
I'M NATIONAL
OAHU
MATTHEW MATTIX, SECRET AGENT FOR METRIC. MY MISSION IS TO CONVINCE YOU THAT METRIC IS BEST!
OUT THAT MEANS WE'LL HAVE TO CHANGE ALL OUR SPORTS
BUT THAT MEANS WE'LL HAVE TO CHANGE ALL OUR SPORTS
OH NO! LA OLYMPIC SPORTS ARE ALREADY METRIC
TRUE!
TRUE!
BUT WHAT ABOUT BASEBALL?
BUT WHAT ABOUT BASEBALL?
MEASUREMENT ISN'T IMPORTANT IN BASEBALL. THE FIELD WILL REMAIN THE SAME SIZE

A holds _____ mL

B holds _____ mL

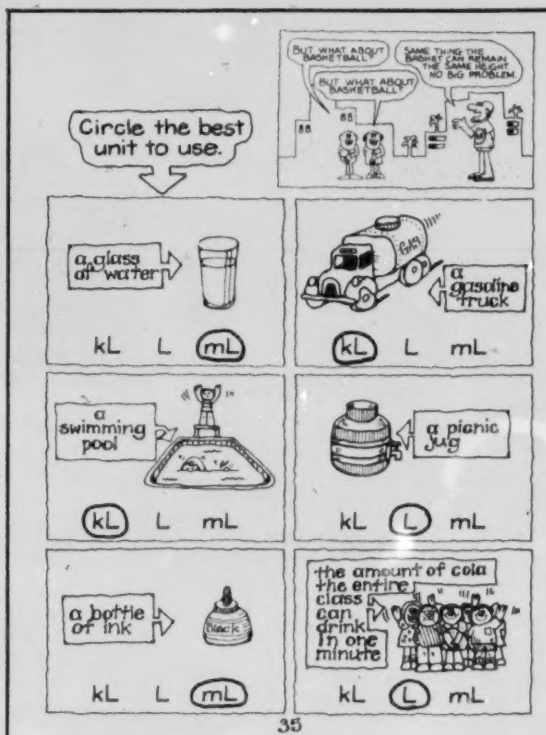
C holds _____ mL

D holds _____ mL

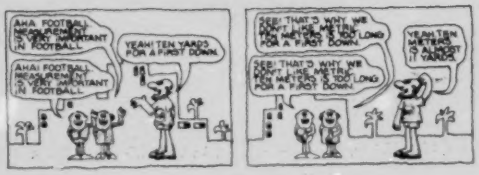
SEAT WORK

1. What is the combined capacity of A and B?
2. What is the combined capacity of C and D?
3. What is the combined capacity of all 4 containers?

34


Circle the best unit to use.
BUT WHAT ABOUT BASKETBALL?
BUT WHAT ABOUT BASKETBALL?
SAME THING. THE BASKET CAN REMAIN THE SAME HEIGHT. NO BIG PROBLEM.
a glass of water
kL L mL
a gasoline truck
kL L mL
a swimming pool
kL L mL
a picnic jug
kL L mL
a bottle of ink
kL L mL
the amount of cola the entire class can drink in one minute
kL L mL

35


AHA! FOOTBALL MEASUREMENT IS VERY IMPORTANT IN FOOTBALL.
YEAH! TEN YARDS FOR A FIRST DOWN.
AHA! FOOTBALL MEASUREMENT IS VERY IMPORTANT IN FOOTBALL.
SEE! THAT'S WHY WE DON'T USE METRIC. YOU METERS IS TOO LONG FOR A FIRST DOWN.
YEAH! TEN METERS IS ALMOST 11 YARDS.
SEE! THAT'S WHY WE DON'T USE METRIC. YOU METERS IS TOO LONG FOR A FIRST DOWN.

Can you unscramble these words which deal with measuring liquids?

1. tierl liter
2. limitiller milliliter
3. tilerolik kiloliter
4. bucic cernideret cubic decimeter
5. quidil liquid
6. dratugade yecrilnd graduated cylinder
7. ropu pour
8. eelirtinct centiliter
9. cidetilre deciliter
10. trohiletec hectoliter

36

the 4M company

section 9 · mass (weight)

Objectives: Given an object and a choice of the metric units gram, kilogram, and metric ton, select a unit of appropriate size for determining the mass (weight).

Given a small object (mass up to 100g), a two-pan balance, and a set of metric weights (50g, 20g, 10g, 10g, 5g, 2g, 2g, and 1g), determine the mass (weight) of the object.

Given a bathroom scale calibrated in kilograms, determine one's own weight to the nearest kilogram.

Materials: 1-kilogram weight, 1-hectogram weight, 1-dekagram weight, 1-gram weight, page 53 of the Teacher's Guide (for dg, cg, mg weights); two-pan balance; set of metric weights including 50g, 20g, 10g, 10g, 5g, 2g, 2g, 1g; a pencil and 6 or 7 other objects under 100g to weigh on the balance; metric bathroom scale,; plastic cubic decimeter, 12 one-meter sticks taped to form a cubic meter (from Section 7, activity 3); Optional--100 pennies, 20 nickels, 10 dimes, 4 quarters, and a dollar bill for activity 7

Vocabulary: mass, weight, metric ton, kilogram, hectogram, dekagram, gram, decigram, centigram, milligram, two-pan balance, spring scale

SUGGESTED PROCEDURE AND ACTIVITIES:

1. Return to the chart on page 2 and review the use of metric prefixes and their spellings. Then introduce the units of weight. It is possible to have a model for each of the seven metric units: a kilogram, a hectogram, a dekagram, a gram, a decigram, a centigram, and a milligram. The latter three can be obtained by having students cut out the figures on page 37 of their books.

   Display these seven units and let students "feel" each weight. Observe that ten milligrams equal a centigram, etc.

   Discuss the use of each commonly used unit: milligram in medicine, grams for small objects, kilograms for heavier objects. Introduce the metric ton as the unit used to weigh very heavy things, like a shipload of grain or a trainload of steel. A metric ton is 1000 kilograms and the symbol is "t".

   Write the units "gram", "kilogram", and "metric ton" on the chalkboard and ask, "Which unit would I use to weigh an elephant? A spoon? A man?" Repeat. Let students name things to weigh. Refer to the actual units in posing the questions. Then assign page 39.

2. Demonstrate how to use a two-pan balance and metric weights to measure the mass

of a small object in grams. Explain the principle of the balance, that when the two pans are level the mass (weight) on one pan is the same as the mass (weight) on the other. Begin by using only 1-gram weights, if available, to measure a very light object like a pencil. Then measure a heavier object (about 50 g) to demonstrate the use and advantage of a set of various-sized weights. To measure any object 100 g or less you will need a set of weights that includes the following: 50 g, 20 g, 10 g, 10 g, 5 g, 2 g, 2 g, and 1 g.

3. Assign pages 40 and 41. On page 40 students are to use the weights shown there to form combinations for all weights between 1 g and 50 g (whole number of grams only). While the class works on page 40 supervise three or four students at a time while they use the balance and metric weights to measure five small objects (each less than 100 g).

4. Introduce the bathroom scale. Explain that we could use a large two-pan balance and kilogram weights to weigh objects like people, but instead we invented the spring scale. When we step on the scale a spring is compressed. The heavier we are, the more we compress the spring. The spring is connected to a dial that is calibrated to indicate mass (weight). Explain how to read the dial, then let students weigh themselves. Emphasize that a weight of 40 kg means it would take 40 1-kg weights to balance that person on a large two-pan balance (or on a teeter totter).

5. Remind students that the inventors of the metric system wanted all their units to be logically related. They related the units of length and capacity by defining the liter as one cubic decimeter. Use a liter measure and a plastic cubic decimeter to demonstrate this relationship again. Explain that the units of length and capacity are related to mass (weight) as follows: one liter of pure water at 4° Celsius weighs one kilogram. No such planned, logical relationship exists between the English units of feet and quarts and pounds. Use a scale or balance and metric weights and the plastic decimeter cube and water to see how close to one kilogram your liter of water weighs. Discuss your sources of error: temperature and purity of the water, inaccuracy of the scale or weights or liter measures, etc. Use page 42 to summarize your discussion.

6. Use page 43, the cubic decimeter, and the cubic meter made from 12 meter sticks (Section 7, #3) to illustrate two relationships: 1) a m^3 holds 10 x 10 x 10 = 1000 liters of water, and 2) a m^3 of water would weigh a metric ton (since each liter weighs 1 kg).

7. (Optional). As a group activity ask the following question: "Which would weigh more, a dollar's worth of pennies, a dollar's worth of nickels, a dollar's worth of dimes, a dollar's worth of quarters, or a dollar bill?" Have the students guess their order by weight and write it on the chalkboard, from heaviest to lightest. Then use a balance or scale to check their guesses.

GRAM

dg

cg

mg

Carefully cut out each of these four rectangles. Hold each one in your hand to feel the approximate mass of a gram, a decigram, a centigram, and a milligram.

37

Circle the best unit to use.

pencil — (g) kg t

car — g (kg) (t)

cup — (g) kg t

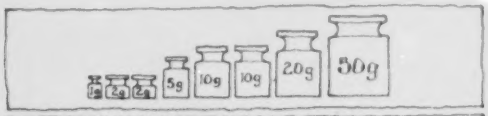
man — g (kg) t

airplane — g kg (t)

sack of rice — g (kg) t

39

NO WE CANNOT LIVE IF THE ENGLISH SYSTEM METRIC IS TERRIBLE
NO WE CANNOT LIVE IF THE ENGLISH SYSTEM METRIC IS TERRIBLE
GRRRR
GRRRR



With these weights we can weigh anything from 1 gram to 100 grams.

For example,
68g=50g+10g+5g+2g+1g

Number a sheet of paper from 1 gram to 50 grams.

Then list the combination of weights which would add up to that number.

1g=1g
2g=2g
3g=2g+1g
4g=

40

MAKE MINE METRIC!
MAKE MINE METRIC!
DID YOU SEE THE LOOK IN THAT DOG'S EYES?
DID YOU SEE THE LOOK IN THAT DOG'S EYES?
ONE DAY LATER ON KALIA:
BUT IT'S SO SIMPLE THE BASE UNIT AND
NO NEVER! UNITS ARE BETTER THAN LITERS!

Weigh 5 things.

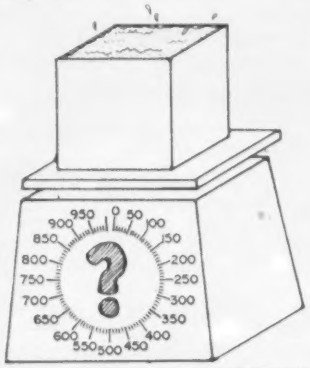
1 weighs _____
2 weighs _____
3 weighs _____
4 weighs _____
5 weighs _____

41

34

Another name for a cubic decimeter is: *liter*

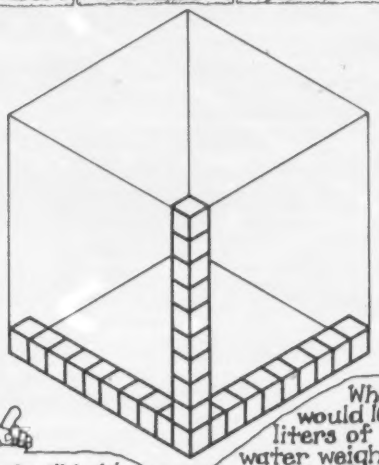
A liter of water weighs: *1 kg*



What would 7 liters of water weigh? *7 kg*

42

10 MILLILITERS = 1 CENTILITER
4 OUNCES = 1 GILL
10 CENTILITERS = 1 DECILITER
4 GILLS = 1 PINT
10 DECILITERS = 1 LITER
2 PINTS = 1 QUART
OH! OH!



A m^3 will hold $10 \times 10 \times 10 = 1000$ liters

What would 1000 liters of water weigh? *1000 kg or 1 metric ton*

43

the 4M company

section 10. decimals: addition and subtraction

Objectives: Given a three-place decimal, write the next four three-place decimals in sequence.

Given a pair of one-, two-, or three-place decimals, find their sum.

Given a pair of one-, two-, or three-place decimals, find their difference.

Materials: meter stick marked in millimeters

Vocabulary: decimal, decimal point, tenths of a meter, hundredths of a meter, thousandths of a meter

SUGGESTED PROCEDURE AND ACTIVITIES:

1. Return to the chart on page 2. Observe that decimeters are tenths, centimeters are hundredths, and millimeters are thousandths of a meter. Explain that decimal numeration is the same as whole number numeration. The first place to the right of the decimal is the tenths place, the second is the hundredths place, and the third is the thousandths place.

   On page 44 students are to read the decimal expressions orally. For example, 3.16 should be read "three and sixteen hundredths". Note, the decimal point is read as "and".

2. Using a meter marked in millimeters as a model, point to the 1 mm mark and write

   0.001 m

   on the board.

   "This is one one-thousandth of a meter." Continue in sequence, writing 0.002 m, 0.003 m, etc. Then ask students to call out the next number in the sequence. Skip to 0.099 m and ask for the next number. Explain that since 100 follows 99, 0.100 m is the next number. Other examples: 2.199 m; 6.299 m, etc. Special attention should be called to 0.999 m, whose successor is 1.000 m.

   Explain that decimals can be read in two ways. For instance, 0.199 m is:

   1) "zero point one nine nine meters; or
   2) "one hundred ninety-nine thousandths of a meter".

3. Page 45 is designed to test the student's understanding of decimal numeration. Check each student carefully.

4. Review how to add and subtract decimals. The decimal points are lined up, and we proceed as in regular addition or subtraction, with the decimal being brought straight down in the answer. Pages 46 and 47 provide practice.

5. Page 48 contains special problems.

Write the following problem on the board:

$$\begin{array}{r} 4.1\ \text{m} \\ +2.275\text{m} \\ \hline \end{array}$$

Explain that since one-tenth of a meter is the same as 100 millimeters (show a meter stick), we merely fill in with zeros. The rule: always fill in with zeros, then compute.

$$\begin{array}{r} 4.100\text{m} \\ +2.275\text{m} \\ \hline \end{array}$$

Then assign page 48.

four and three hundred seven thousandths

ones	tenths	hundredths	thousanths
4	.	3	07

and

Read the following.

4.7	6.45	8.62	3.91	99.3
18.901	14.003	6.04	8.01	6.009
27.4	8.07	9.32	8.040	1.999
0.001	0.04	0.6	0.496	0.197
5.2	5.22	5.222	5.002	5.022

44

Write the next four decimals.

0.049m	0.050m	0.051m	0.052m	0.053m
2.109m	2.110m	2.111m	2.112m	2.113m
6.699m	6.700m	6.701m	6.702m	6.703m
8.999m	9.000m	9.001m	9.002m	9.003m
5.608m	5.609m	5.610m	5.611m	5.612m

45

Add.

3.172m + 2.014m = 5.186m	0.76m + 1.13m = 1.89m	5.905m + 1.061m = 6.966m
5.003m + 2.715m = 7.718m	8.132m + 1.036m = 9.168m	1.237m + 0.001m = 1.238m
1.123m + 3.214m = 4.337m	9.999m + 0.001m = 10.000m	9.99m + 0.01m = 10.00m
4.147m + 3.145m = 7.292m	0.413m + 2.823m = 3.236m	1.01m + 2.34m = 3.35m

46

Subtract.

7.95m − 3.14m = 4.81m	8.2m − 1.1m = 7.1m	3.978m − 1.234m = 2.744m
0.47m − 0.13m = 0.34m	0.99m − 0.44m = 0.55m	0.999m − 0.123m = 0.876m
1.999m − 0.991m = 1.008m	9.999m − 9.909m = 0.090m	0.909m − 0.303m = 0.606m
4.932m − 1.108m = 3.824m	3.718m − 1.146m = 2.572m	9.194m − 3.912m = 5.282m

47

38

Add or subtract.

$\begin{array}{r} 4.643 \\ +\ 1.2 \\ \hline 5.843 \end{array}$	$\begin{array}{r} 3.6 \\ +\ 1.75 \\ \hline 5.35 \end{array}$	$\begin{array}{r} 8.97 \\ +0.617 \\ \hline 8.987 \end{array}$
$\begin{array}{r} 7.952 \\ -\ 1.5 \\ \hline 6.452 \end{array}$	TRICKY! $\begin{array}{r} 3.9 \\ -\ 1.72 \\ \hline 2.18 \end{array}$	$\begin{array}{r} 17.45 \\ -\ 3.4 \\ \hline 14.05 \end{array}$
$\begin{array}{r} 1.6 \\ +3.25 \\ \hline 4.85 \end{array}$	$\begin{array}{r} 8.789 \\ +1.21 \\ \hline 9.999 \end{array}$	$\begin{array}{r} 0.004 \\ +0.6 \\ \hline 0.604 \end{array}$
$\begin{array}{r} 4.916 \\ -\ 1.6 \\ \hline 3.316 \end{array}$	$\begin{array}{r} 66.4 \\ -14.12 \\ \hline 52.28 \end{array}$ TRICKY!	$\begin{array}{r} 2.569 \\ -\ 0.1 \\ \hline 2.469 \end{array}$

46

the 4M company

section 11. decimals: multiplication and division

Objectives: Given a pair of one-, two-, or three-place decimals, find their product.

Given a pair of one-, two-, or three-place decimals, find their quotient.

Materials: (Optional) one or two square meters made of cardboard, several cardboard strips 1 dm x 1 m (models for one-tenth of a square meter), several squares 1 dm x 1 dm (models for one-hundredth of a square meter)

Vocabulary: decimal, decimal point, tenths of a square meter, hundredths of a square meter

SUGGESTED PROCEDURE AND ACTIVITIES:

1. Page 49 can serve as an aid in introducing multiplication of decimals. The first example indicates that l x w = A. The second example shows a rectangle which is 1.2 m wide and 2 m long. By counting pieces, we see that the total area is 2.4 m^2. There are two squares, and there are four strips, each of which are one-tenth of a square meter.

2. On page 50 have the class try to determine the area by counting up the various pieces. In the first example there are six m^2, eight tenths of a m^2, and two hundredths of a m^2. The area is 6.82 m^2. In the second example there are four m^2, seven tenths of a m^2, and three hundredths. Hence, the area is 4.73 m^2. Write the three areas on the board as follows:

$$1.2\,m \times 2\,m = 2.4\,m^2$$
$$3.1\,m \times 2.2\,m = 6.82\,m^2$$
$$1.1\,m \times 4.3\,m = 4.73\,m^2$$

Then have the class multiply the sides of each rectangle, ignoring for the moment the decimals.

$$\begin{array}{r} 1.2 \\ \times\ 2 \\ \hline 24 \end{array} \qquad \begin{array}{r} 2.2 \\ \times 3.1 \\ \hline 22 \\ 66 \\ \hline 682 \end{array} \qquad \begin{array}{r} 4.3 \\ \times 1.1 \\ \hline 43 \\ 43 \\ \hline 473 \end{array}$$

Observe that the numerical parts are the same as the area we calculated by adding up pieces. See if the class can discover how to place the decimal properly. There must be as many decimal places (places to the right of the decimal) in the product as there are in both factors. Work a few examples.

3. Assign page 51. Students are to place the decimal point in each product.

4. Page 52 provides practice. You may want to make up more problems for your students.

5. Page 53 can serve as an introduction to

division of decimals. The example with whole numbers shows that if we know the area and one side, we can divide to find the other side. The second example poses a similar problem with a rectangle whose sides are decimals. Let the class divide

$$2.3\overline{)2.53}$$

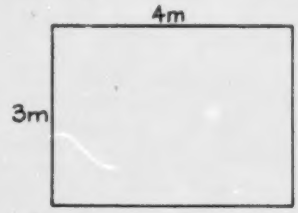
to get the answer. The placement of the decimal point in the quotient is, of course, crucial. There must be two decimal places altogether in the divisor and quotient, since there are two in the total area. An easy way to proceed is to move decimals over in both the divisor and dividend,

$$2.3\overline{)2.53}$$

then move the decimal straight up in the answer.

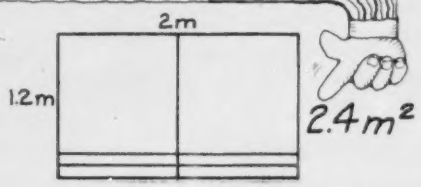
6. Assign pages 54 and 55.

Remember how to find area? These are scale drawings of square meters.



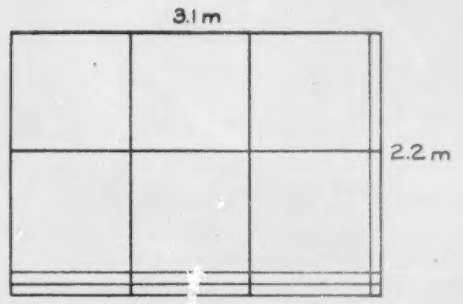
Area = 3 m × 4 m = 12 m²

Try this one?



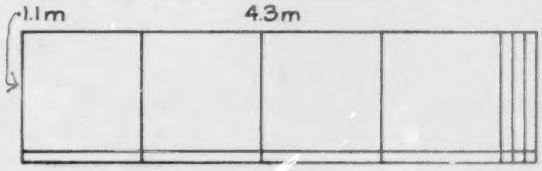
There are 2 square meters, and 4 strips. Each strip is one tenth of a square meter.

49



What is the area? Count up the pieces. Ten strips make 1 larger piece.

6.82m²



Area? 4.73m²

50

10 MILLI-TERS = 1 CENTI-LITER
10 CENTI-LITERS = 1 DECI-LITER
2 PINTS = 1 QUART
10 DECA-TERS = 1 LITER
10 LITERS = 1 DEKA-LITER
4 QUARTS = 1 GALLON

Place the decimal.

4.6 × 1.2 = 552	2.7 × 9.3 = 25.11	7.6 × 3.7 = 28.12
4.75 × 2.3 = 10.925	3.48 × 1.2 = 4.176	0.49 × 1.6 = .784
4.132 × 1.361 = 5.623652	9.132 × 8.112 = 74.078784	

51

Multiply.

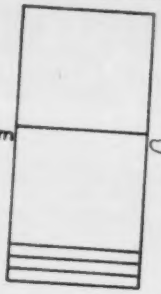
2.4 × 3 = 7.2	3.14 × 5 = 15.70	6.23 × 4 = 24.92	8.97 × 2 = 17.94
1.3 × 2.4 = 3.12	3.2 × 1.7 = 5.44	8.3 × 1.7 = 14.11	5.5 × 7 = 38.5
1.342 × 4 = 5.368	2.004 × 8 = 16.032	27.1 × 0.3 = 8.13	1.7 × 1.2 = 2.04

52

42

One side = 4 cm
Area = 32 cm²
Other side = ?

$$4\overline{)32}\quad 8,\ 32,\ 0$$



One side = 2.3 m
Area = 2.53 m²
Other side = ?

$$2.3\overline{)2.53}\quad 1.1$$

1.1 m

53

Place the decimal point.

$$3\overline{)1.11}\quad .37,\ 9,\ 21,\ 21,\ 0$$

$$1.3\overline{)4.81}\quad 3.7,\ 39,\ 91,\ 91,\ 0$$

$$0.4\overline{).888}\quad 2.22,\ 8,\ 8,\ 8,\ 8,\ 0$$

$$2.1\overline{)1.26}\quad .6,\ 126,\ 0$$

$$1.4\overline{)57.4}\quad 41.,\ 56,\ 14,\ 14,\ 0$$

$$0.3\overline{)993}\quad 3310,\ 9,\ 9,\ 3,\ 3,\ 0$$

$$40\overline{)8.4880}\quad .2122,\ 80,\ 48,\ 40,\ 88,\ 80,\ 80,\ 80,\ 00$$

$$1.1\overline{)8.547}\quad 7.77,\ 77,\ 84,\ 77,\ 77,\ 77,\ 0$$

$$1.2\overline{)14.4}\quad 12.,\ 12,\ 24,\ 24,\ 0$$

54

DIVIDE DECIMALS.

$$0.4\overline{)1.04}\quad 2.6$$

$$0.6\overline{)133.2}\quad 222$$

$$0.5\overline{)26.5}\quad 53$$

$$0.8\overline{)2.56}\quad 3.2$$

$$0.7\overline{)36.4}\quad 52$$

$$0.2\overline{)7.42}\quad 37.1$$

$$1.2\overline{)25.2}\quad 21$$

$$1.8\overline{)0.396}\quad .22$$

$$2.5\overline{)6.00}\quad 2.4$$

$$0.35\overline{)4.375}\quad 12.5$$

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the 4M company

section 12 · conversion between metric units

Objectives: Given the six common metric prefixes, write their numerical values.

Given the name of a common metric unit, spell it.

Given a measurement in one metric unit, convert it to another specified metric unit.

Materials: none

Vocabulary: kilo-, hecto-, deka-, deci-, centi-, milli-, 1000, 100, 10, 0.1, 0.01, 0.001, convert, decimal point

SUGGESTED PROCEDURE AND ACTIVITIES:

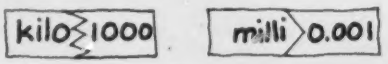
1. Return to page 2 and review the chart.

2. Quiz the students to see if they know the values of the six metric prefixes and can spell the common metric units. Provide drill and practice for those students who have not mastered these skills.

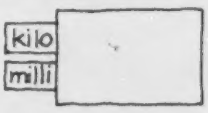
3. Make flashcards (or have students make them) and have students drill one another on the prefixes, their spellings and meanings.

4. Play Concentration. Use page 55 of the Teacher's Guide to make several decks of cards, or have students mark on precut cards. Each deck of cards consists of twelve cards, one for each of the following: kilo, hecto, deka, deci, centi, milli, 1000, 100, 10, 0.1, 0.01, and 0.001. The cards are placed face down in three rows of four each. The game is best with two players. The first player turns over two cards, one at a time. If they match (eg., kilo, 1000) the player keeps the cards and gets another turn. If they do not match, the player turns them face down again in their original places and the second player takes his turn. The object of the game is for the players to remember the exposed cards and their locations so that they can make as many matches as possible when it is their turn. The player with the most cards (i.e. matches) at the end of the game is the winner.

5. Make simple puzzles like the following:



Place all jagged edges of prefixes under a sheet of paper and have students try to match pieces.



6. Write

kilo
+ hecto

on the board. Ask students to replace the prefixes with their value, then add them up:

kilo = 1000
+ hecto = 100
1100

Then assign page 56.

Page 59 provides more practice. You may wish to provide further practice. Let the students use the chart as an aid in converting. Provide more drill if it is necessary.

7. Page 57 illustrates how to convert from one metric unit to another. Use the page to demonstrate the method. To convert 3 kg = ___ g, place your finger on the unit whose numerical value is given (kg), then count over until you get to the other unit (g). Since you moved three places to the right, we must move the decimal point three places to the right. Thus,

3 kg = 3000 g

Note that with a whole number, the decimal is to the right of the one's digit, even though not written. Work several other examples.

Page 58 illustrates another example:

7 mL = ____ dL

Place your finger on mL, count over to dL. Since you went 2 places to the left, move the decimal 2 places to the left.

.07

Note that we have to add zeros to properly place the decimal point.

Use a meter marked in millimeters to illustrate that the moving finger short cut really works. Note that 3 dm = 300 mm. "Using the chart, we go two places to the right in going from dm to mm. Hence 3 dm = 300 mm."

3 dm = 300 mm

45

1. deci = 0.1
   + centi = 0.01
   = 0.11

2. hecto = 100
   + kilo = 1000
   = 1100

3. milli = 0.001
   + centi = 0.01
   = 0.011

4. deka = 10
   + hecto = 100
   = 110

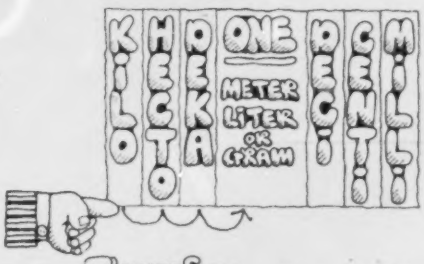
5. kilo = 1000
   + deka = 10
   = 1010

6. deci = 0.1
   + milli = 0.001
   = 0.101

7. deka = 10.0
   + deci = 0.1
   = 10.1

8. hecto = 100.
   + centi = 0.01
   = 100.01

3 kg = ? g

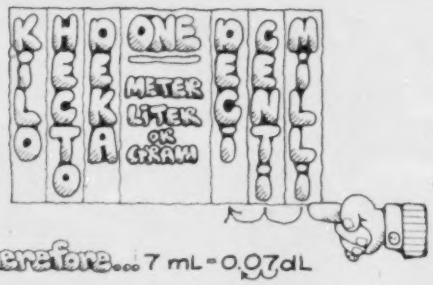


Therefore... 3 kg = 3000 g

4 dam = 40 m
6 dL = 600 mL
104 hg = 10400 g
42 cm = 420 mm
0.4 hL = 40 L
2.1 km = 2100 m

SIX DAYS LATER ON LANA:
EZRA POUND I PRESUME?
YES BUT WHO ARE YOU?
LANA
MATTHEW MATTA, SECRET AGENT FOR METRIC, SET HIMSELF TO CONVINCE EZRA THAT METRIC IS BEST
A POUND IS A POUND'S A POUND

7 mL = ? dL



Therefore... 7 mL = 0.07 dL

427 cL = 4.27 L
6276 m = 6.276 km
67 mg = 6.7 cg
4.5 dag = 0.045 kg
526 cm = 0.526 dam
47 dm = 4.7 m

5 kL = 5000 L
4.1 kg = 410 dag
6000 mg = 6 g
8000 mL = 8 L
4 mg = 0.004 g
18 mL = 0.018 L
425 mm = 0.425 m
4 cL = 0.04 L
465 cg = 4.65 g
6 m = 6000 mm
6 hm = 600 m
8 hL = 800 L
14 hg = 1400 g
1.6 L = 1600 mL
4.2 g = 4200 mg
4000 m = 4 km
8600 L = 8.6 kL
14000 g = 14 kg
2 m = 0.2 dam
44 L = 4.4 daL

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section 13 · temperature

Objectives: Given a Celsius thermometer, read the temperature to the nearest degree.

Given the three temperatures 100° C, 0° C, and 37° C identify them as the boiling point of water, the freezing point of water, and normal body temperature.

Materials: 2 glasses of water, metric thermometers, ice, 1 cup of salt, pan or other container

Vocabulary: temperature, thermometer, degrees Celsius, °C, "below zero", "minus __ degrees"

SUGGESTED PROCEDURE AND ACTIVITIES:

1. Page 60 illustrates the key features of the Celsius thermometer and its advantages over the Fahrenheit scale. Explain that the students must remember the three Celsius temperatures. Drill will help.

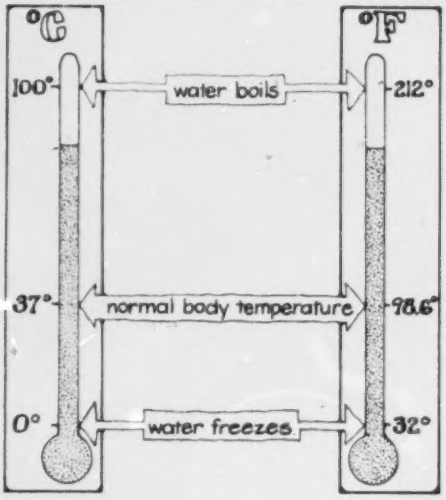
2. Place a thermometer in a pan of ice water and stir continuously. Record the temperature every minute (without removing thermometer from the water). After five minutes, carefully stir in a cup of salt. Keep stirring and record temperature every minute for five more minutes. Students are to record the temperatures on page 61. This illustrates that foreign factors can alter the freezing point of water. 0° C is for pure water.

3. If a hot plate is available, repeat the experiment with boiling water.

4. Place one glass of water in the shade and another in direct sunlight. Place a Celsius thermometer in each. Record the temperature every hour.

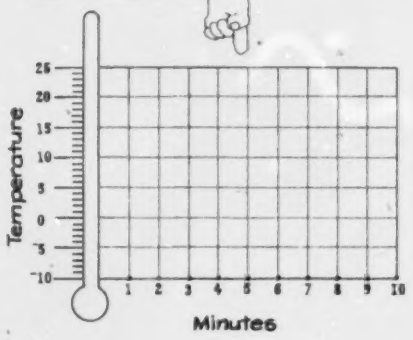
5. In activity #2 above some temperatures were below zero. Discuss what negative temperatures mean, cold weather, etc.

6. Check out all students to see that they can read a thermometer correctly. Page 62 will help to check this skill.



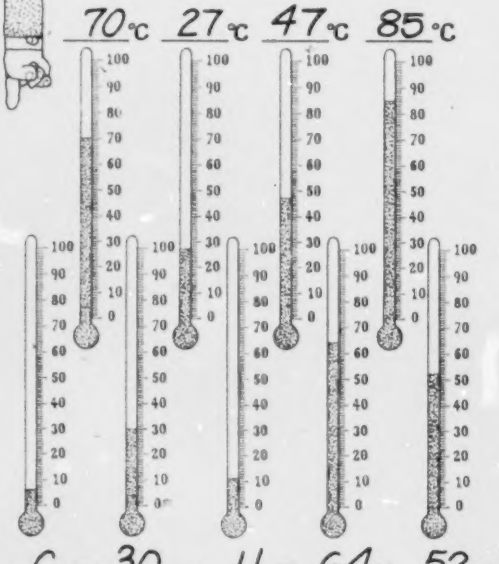
60

How salt affects the temperature of ice water:



61

Read these temperatures.



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section 14 · more metric prefixes

Objectives: Explain that the modern metric system uses more than the six common metric prefixes previously learned.

Materials: none

Vocabulary: mega-, giga-, tera-, peta-, exa-, micro-, nano-, pico-, femto-, atto-

SUGGESTED PROCEDURE AND ACTIVITIES:

1. The original metric system contained only six metric prefixes, those we have encountered thus far. Since then scientists have found the need for very large measures and very small measures. To meet this need, more prefixes have been added. Page 63 lists these prefixes.

   Go over the prefixes and (just for fun) see if the students can give the number names for them: mega (meg´ah) is one million, giga (ji´gah) is one billion, tera (tear´ah) is one trillion, peta (pet´ah) is one quadrillion, and exa (ex´ah) is one quintillion. Similarly, micro (mike´roh) is one-millionth, nano (nan´oh) is one-billionth, pico (pee´koh) is one-trillionth, femto (fem´toh) is one quadrillionth, and atto (at´toh) is one-quintillionth. It is not necessary for children to remember these numbers. Note: a complete chart including symbols and pronunciations appears on page 9 of the Make Mine Metric Minicourse in the Appendix of this Teacher's Guide.

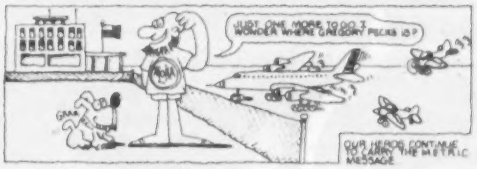
2. Page 64 is just for fun. If students replace a number with the corresponding prefix, a word will emerge.

3. For extra credit activities challenge students to 1) think of or look in the dictionary for words that use the prefixes listed on page 63, 2) make up some exercises of their own like those on page 64 to share with the class.

   Consider: 10 cards = "dekacards"
   1000 pede = "millipede"
   1000 uea = "kilouea"

exa means 1 000 000 000 000 000 000
peta means 1 000 000 000 000 000
tera means 1 000 000 000 000
giga means 1 000 000 000
mega means 1 000 000
kilo means 1 000
hecto means 100
deka means 10
deci means 0.1
centi means 0.01
milli means 0.001
micro means 0.000 001
nano means 0.000 000 001
pico means 0.000 000 000 001
femto means 0.000 000 000 000 001
atto means 0.000 000 000 000 000 001

63



0.001 lanitown = milli lanitown
0.1 mate = deci mate
0.001 tant = milli tant
1000 manjaro = kilo manjaro
100 r = hecto r
1000 000 lomania = mega lomania
1000 000 000 ntic = giga ntic
0.000 001 nesia = micro nesia
1000 000 000 000 tory = tera tory
0.000 000 000 000 000 001 rney = atto rney

64

the 4M company

section 15 · review

Objectives: Review previous topics in preparation for a final test.

Materials: final tests

SUGGESTED PROCEDURE AND ACTIVITIES:

1. Turn to page 2 and review the chart. Proceed page by page through the student booklet, reviewing each topic.

2. Assign pages 65-68 of the student book. For page 68 you will have to write the following secret code on the chalkboard.

A	C	D	E	G	I	L
1°	2°	3°	4°	5°	6°	7°

M	N	R	S	Y	O
8°	9°	10°	11°	12°	13°

3. If at all possible show a movie (or filmstrip) to the class to provide a brief background histroy of the English and Metric systems of measurement, give reasons for the U.S. conversion to metrics, and summarize the basic features of the metric system and what makes it superior to the English system. Several films and filmstrips are available.

4. Duplicate the list of review questions provided on page 57 of the Teacher's Guide and assign students to write the answers to the questions. These review questions are fairly difficult. Allow students to work together to answer them and to use whatever sources of information they wish. After the students have written their answers discuss the review questions and answers as a class. Provide explanations and further review as needed before administering the final test.

5. Administer the final test. (For the pilot test version of THE 4M COMPANY, copies of the final test will be provided as part of the evaluation package.)

6. The last page of the student book is an official certificate that indicates the student "has assisted Matthew Mathx in the accomplishment of his M.E.T.R.I.C. mission and is thereby made an honorary agent for M.E.T.R.I.C. (Measurement Education Training and Research Investigation Committee)".

   Upon the successful completion of the final exam, students may have the teacher enter their names on their "official certificates".

ONE WEEK LATER IN HAWAII
GREGORY PACKS HIS PREPARED
YES, BUT WHO ARE YOU?
HAWAII
MATTHEW KATTIK, SECRET AGENT FOR METRIC, MY MISSION IS TO CONVINCE YOU THAT METRIC IS BEST!
THAT'S IMPLAUSIBLE!

4dm	20cm	100mm	5dm	7dm	300mm
50cm	400mm	1dm	80cm	30cm	10cm
7dm	5dm	10cm	900mm	400mm	80cm
800mm	9dm	800mm	50cm	1dm	7dm
60 cm	100mm	500mm	6dm	900mm	200mm
5dm	90cm	80cm	700mm	10cm	8dm

Shade any two squares that touch so that the sum is 1 meter.

Can you unscramble these letters to form metric units?

1. rteem meter
2. malgkoir kilogram
3. tilre liter
4. ceerthotli hectoliter
5. aaedmgkr dekagram
6. eeeicdtmr decimeter
7. ciintleert centiliter
8. malilmrig milligram
9. mgar gram
10. ergdese slicesu degrees celsius

Can you do these problems?

46.21 + 2.54 = 48.75	0.435 + 0.61 = 1.045	4.95 − 1.2 = 3.75
2.41 × 1.1 = 2.651	6.4 × 0.5 = 3.20	8.002 × 3 = 24.006
2.1 ⟌ 6.93 = 3.3	0.4 ⟌ 9.24 = 23.1	6 ⟌ 0.738 = 0.123

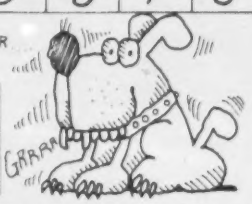
SECRET CODE

100°C − 92°C	100°C − 88°C
8°C	12°C
M	Y

100°C − 91°C	100°C − 99°C	100°C − 92°C	100°C − 96°C
9°C	1°C	8°C	4°C
N	A	M	E

100°C − 94°C	100°C − 89°C
6°C	11°C
I	S

100°C − 93°C	100°C − 87°C	100°C − 95°C	100°C − 94°C	100°C − 98°C
7°C	13°C	5°C	6°C	2°C
L	O	G	I	C



100°C − 99°C	100°C − 91°C	100°C − 97°C
1°C	9°C	3°C
A	N	D

100°C − 90°C	100°C − 96°C	100°C − 99°C	100°C − 89°C	100°C − 87°C	100°C − 91°C
10°C	4°C	1°C	11°C	13°C	9°C
R	E	A	S	O	N

SECTION 9: Cut out these rectangles to use as weights. They weigh 1 gram, 1 decigram, 1 centigram, and 1 milligram, respectively.

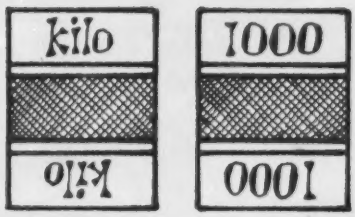
dg

cg

mg

SECTION 12

Masters for the card game Concentration. You may want to duplicate these on construction paper (using a thermofax stencil of this page and a duplicating machine) so each pair of students in your class has a deck. See Section 12, activity #4 for game rules.



kilo	hecto	1000	100
kilo	hecto	1000	100
deka	deci	10	0.1
deka	deci	10	0.1
centi	milli	0.01	0.001
centi	milli	0.01	0.001

SECTION 15: List of review questions to be answered by students prior to the final test.

1. When was the metric system invented and where?

2. What were the three main units of the original metric system:

   length_____ capacity_____ mass (weight)_____

3. List the six prefixes of the original metric system in order from larger to smaller. Write the meaning and the symbol of each prefix beside it.

PREFIX	MEANING	SYMBOL

4. List two reasons why the United states should use the metric system of measurement instead of the English system.

   1.
   2.

5. What metric unit should you use to make each of the following measurements:

   distance from Honolulu to Hilo _____
   height of a person _____
   mass (weight) of a person _____
   thickness of a coin _____
   capacity of a large bucket _____
   area of a cafeteria floor _____
   volume of a bar of soap _____
   mass (weight) of a handful of raisins _____
   capacity of a drinking glass _____

6. Write the next four decimals.

4.627				
16.598				
0.997				

7. Write these decimals.

   Five and sixty-two hundredths meters._____
   Ten and four tenths meters._____
   Thirteen and five hundred twenty-one thousandths liters._____
   Two hundredths of a meter._____
   Thirty-eight thousandths of a liter._____

8. List the following in degrees Celsius. (Use the chart in your book.)

boiling point of water_____
freezing point of water_____
normal body temperature_____

9. Circle the most likely temperature.

a cup of hot coffee	90°C	50°C	10°C
an ice cream bar	70°C	30°C	0°C
a hot day at the beach	90°C	30°C	10°C
a sick person	99°C	39°C	9°C

10. Convert these measurements.

621 cm = _____	m	8 kg = _____	g
425 mL = _____	L	4 m = _____	cm
1500 g = _____	kg	33 cm = _____	mm
138.62 dam = _____	dm	4.26 kg = _____	hg

11. Circle the most likely measurement.

length of a bee	13 mm	80 mm	10 cm
mass (weight) of a can of soup	35 g	450 g	4 kg
height of a basketball player	90 cm	125 cm	180 cm
capacity of an aquarium	1000 mL	5 mL	38 L

12. Why is the metric system easier to learn and use than the English system?

13. Add decimals.

2.673	3.64
+1.864	+10.604

14. Subtract decimals.

4.628	2.68
-2.411	-0.512

15. Multiply decimals.

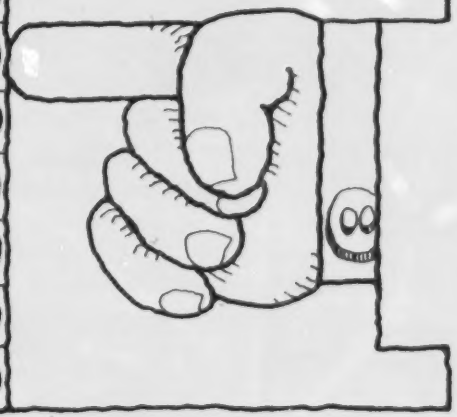
4.62	8.061
x 0.4	x 1.6

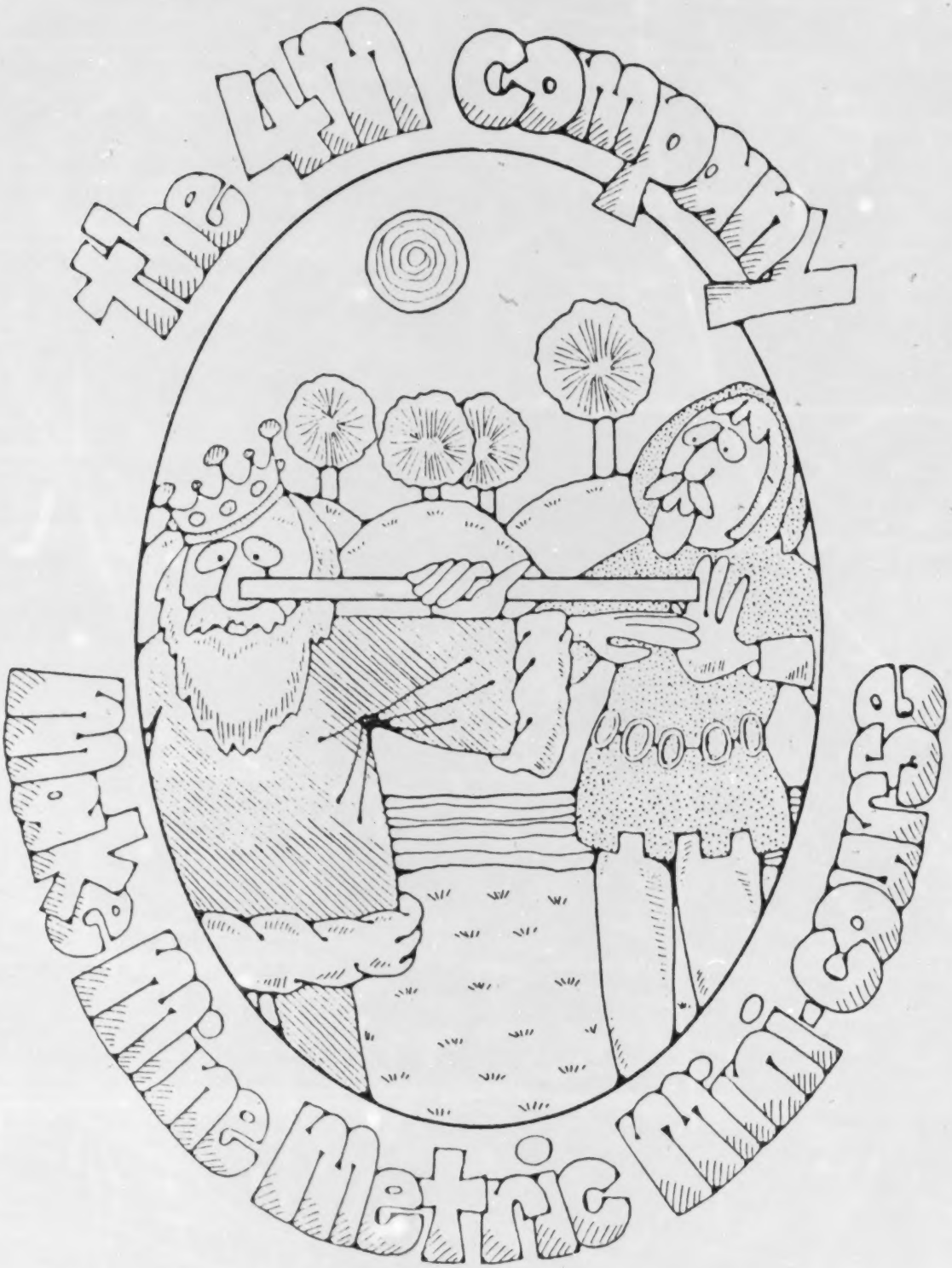
16. Divide decimals.

$0.02\overline{)4.524}$ $1.1\overline{)3.564}$

Learn the metric System

1000	kilometer (km)	kiloliter (kL)	kilogram (kg)
100	hectometer (hm)	hectoliter (hL)	hectogram (hg)
10	dekameter (dam)	dekaliter (daL)	dekagram (dag)
1	meter (m)	liter (L)	gram (g)
0.1	decimeter (dm)	deciliter (dL)	decigram (dg)
0.01	centimeter (cm)	centiliter (cL)	centigram (cg)
0.001	millimeter (mm)	milliliter (mL)	milligram (mg)





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INTRODUCTION

This mini-course is designed to serve two purposes: 1) a quick review of metrics for teachers who have attended a metric workshop; and 2) a basic introduction to the metric system for teachers who have not attended a metric workshop. If studied seriously, we feel the contents of this mini-course can prepare a teacher to teach the metric system. However, don't expect to be an expert right away. Even teachers who have attended a workshop frequently forget much of what they learned. As most teachers know, we usually don't know a subject well until we have taught it a time or two. The same will be true of metrics.

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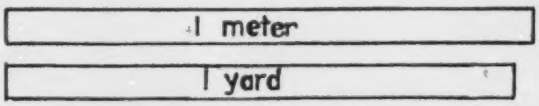
Last Lesson: Metric for Everyday Living . . . . . page 14

LESSON 1: THE METER, THE LITER, AND THE GRAM

The three most common metric units are the meter (for measuring length or distance), the liter (for measuring liquid or granular capacity), and the gram (for measuring weight). Select a meter, a liter, and a gram from your metric supplies.

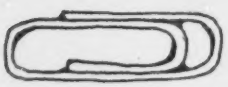
The meter is the main unit of length in the metric system. Stand up and hold the meter stick on the floor against your leg. How high up your leg does it come? To your hip? To your waist? Remember the spot and you'll always have some idea of a meter. A meter is just a little longer than a yard -- 39.36 inches.



The liter is the main unit of capacity in the metric system. It was originally defined to be the capacity of a cube each of whose sides was 1/10th of a meter long.

Take a good look at the liter. Does it appear to be about the size of any English unit? Actually, the liter is slightly larger than a quart (6% larger, to be exact).

Now pick up the gram, the main unit of weight in the metric system. Pretty light, isn't it? If you look at the protein, fat, and carbohydrate content of the sides of cereal boxes you'll notice that the weights are given in grams. A paper clip weighs about one gram. A nickel weighs 5 grams.


weighs 1 gram

weighs 5 grams

These three units - meter, liter, and gram - are the heart of the metric system necessary for everyday measuring. Try to remember the size of each unit: the meter is a little longer than one yard; a liter is a little larger than a quart; and a gram is the weight of a paper clip.

LESSON 2: OTHER UNITS - PRESTO!

In the English system of measurement there are 14 units of length, and there is no systematic relationship between them:

12 inches = 1 foot

3 feet = 1 yard

5½ yards = 1 rod

40 rods = 1 furlong

8 furlongs = 1 mile

etc.

One would have to be a near-genius to remember all the relationships in the English system!

By comparison, the metric system is simple (although it may not seem so at first). In the metric system there is one base unit for each physical property to be measured. To form units larger or smaller than the base units, a system of prefixes, each of which is a power of ten, is used. For units smaller than the base units, the Latin words for tenth, hundredth, and thousandth are used (deci, centi, and milli). To form units larger than the base units, the Greek words for ten, hundred, and thousand are used (deka, hecto, and kilo). The new units are formed by placing the prefixes in front of the base units.

	LENGTH	CAPACITY	MASS (WEIGHT)
1000	kilometer (km)	kiloliter (kℓ)	kilogram (kg)
100	hectometer (hm)	hectoliter (hℓ)	hectogram (hg)
10	dekameter (dam)	dekaliter (daℓ)	dekagram (dag)
1	meter (m)	liter (ℓ)	gram (g)
0.1	decimeter (dm)	deciliter (dℓ)	decigram (dg)
0.01	centimeter (cm)	centiliter (cℓ)	centigram (cg)
0.001	millimeter (mm)	milliliter (mℓ)	milligram (mg)

Whenever kilo is heard, we know immediately that we have 1000 of the base unit, whatever it is. Thus, kilometer is 1000 meters, kiloliter is 1000 liters, kilowatt is 1000 watts, etc. (The watt is a unit of power.) Or, millimeter is 0.001 meter, milliliter is 0.001 liter, etc.

The writing of metric units is simplified by the use of symbols: m stands for milli, c for centi, d for deci, da for deka (the a is needed to distinguish deci from deka, both of which start with d), h for hecto, and k for kilo. Also, m for meter, ℓ for liter, and g for gram. Thus kg is kilogram, mℓ is milliliter, etc. In the next lesson you will practice using these metric prefixes.

LESSON 3: PRACTICE WITH PREFIXES

In this lesson you will practice using metric prefixes. Use the table in Lesson 2 to help you complete the following equations. Answers appear at the end of the Teacher's Guide.

100 grams = hectogram

10 liters = _____

1000 meters = _____

0.001 gram = _____

100 liters = _____

0.01 gram = _____

0.001 meter = _____

0.01 meter = _____

0.001 liter = _____

100 liters = _____

1000 liters = _____

1000 grams = _____

10 meters = _____

0.1 meter = _____

0.1 liter = _____

0.01 liter = _____

0.1 gram = _____

10 grams = _____

Keep going! Try these!

10 cards = dekacards (get it?)

0.1 Arnaz = _____

0.01 mentalist = _____

1000 manjaros = _____

0.001 tary = _____

0.1 mate = _____

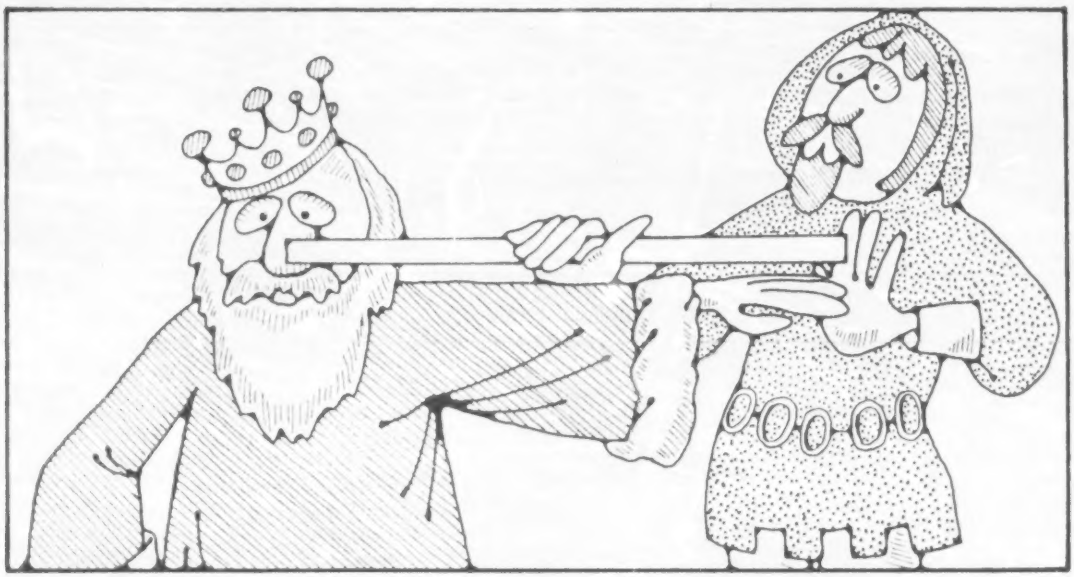
1000 whats? = _____

0.001 scent = _____

0.01 pede = _____

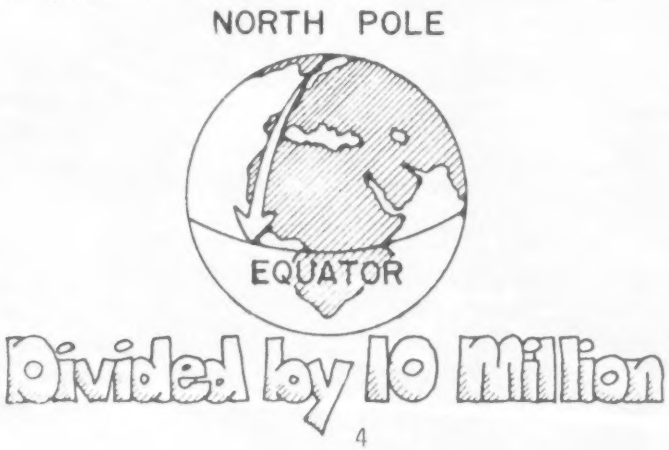
LESSON 4: A BRIEF HISTORY OF THE METRIC SYSTEM

Prior to 1790, the measurement systems of Europe were based on arbitrary objects: an inch was once defined to be the length of 3 kernels of barley corn placed end-to-end; a rod was the combined left feet of the first 16 men coming out of a specific church on Sunday morning; an acre was the amount of land a team of oxen could plow in one day; the yard was the distance from the tip of King Henry I's nose to the tip of his extended middle finger; etc.



A similar hodge-podge of units was used in France at the time of the French Revolution. In 1789, the French Academy of Sciences was requested by the National Assembly to devise a new measurement system. The French Revolution was underway, and because of the antiaristocratic attitude of the French people, a change to a system not based on dimensions of royal monarchs was highly acceptable to them.

In developing the metric system the French scientists had three major objectives. The first objective was to find a unit of length that was measurable and reproducible everywhere, and natural in the physical world. To meet this objective, the meter was defined to be one ten-millionth of the distance from the equator to the north pole.



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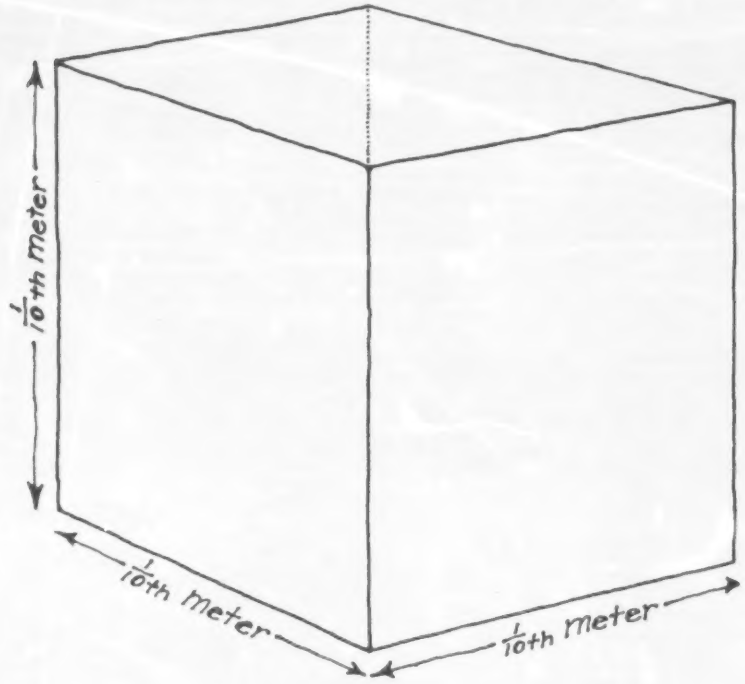
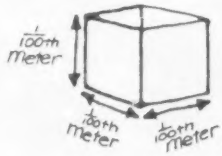
The second objective was to relate the unit of length to other units of measurement. For the main unit of capacity they selected a cube, with each of its sides equal to 1/10th of a meter (cubic decimeter), and called the amount of space contained within this box-shaped figure a "liter."



Liter

For the main unit of mass, the French scientists took a cube with each of its sides equal to 1/100th of a meter (a cubic centimeter), filled this box with pure water at 4° Centigrade, and designated the mass of this water as a "gram." Thus, the meter was used to define both the liter and gram.



Gram

The third objective was to simplify the conversion from one unit to another. We have already seen how a system of prefixes, which are powers of ten, was used to accomplish this objective. Since each metric unit is ten times larger than the next smaller unit, converting from one unit to another can be accomplished by merely moving a decimal point. Thus

35 meters =
- 0.035 kilometers
- 0.35 hectometers
- 3.5 dekameters
- 350 decimeters
- 3500 centimeters
- 35 000 millimeters

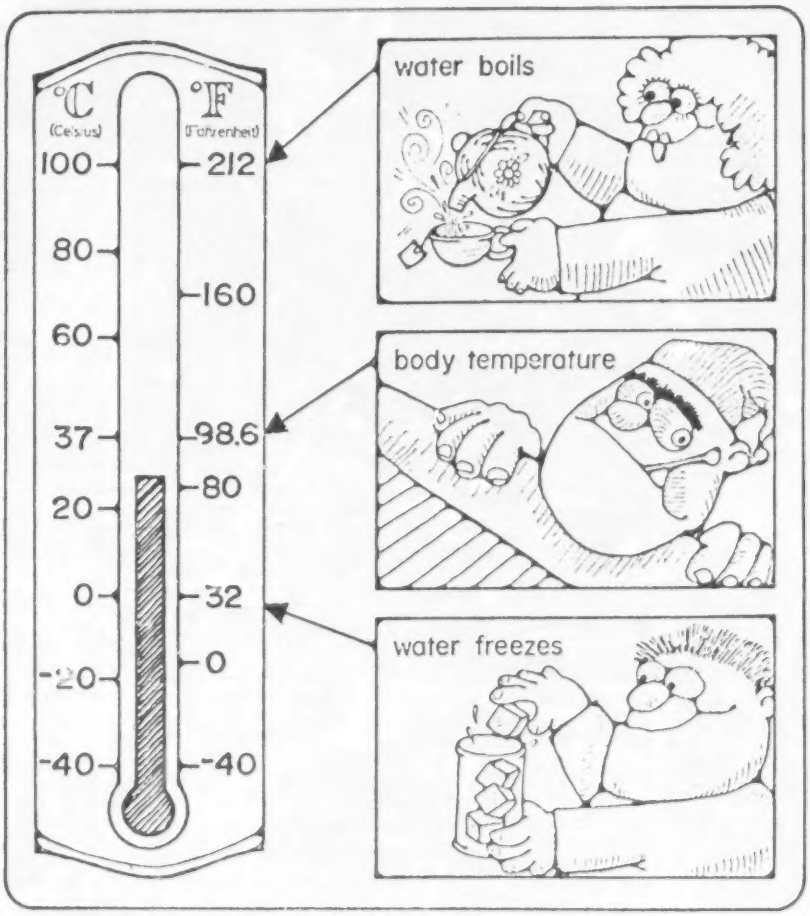
Scientists adopted the metric system immediately, for it made their work much simpler. Nations, on the other hand, have been slow to adopt it. It wasn't until 1840 that the French government made its use mandatory. By 1900, thirty-five nations had officially adopted it, and by the middle of this century, the main holdouts were the English-speaking nations. In 1965, England joined the European Common Market. Since Europe used the metric system, England decided to go metric. The other English-speaking nations soon followed. Ten years later, President Ford signed the Metric Conversion Act of 1975. Finally, after 180 years, the conversion to metric is nearing completion.

LESSON 5: TEMPERATURE

There is one more metric unit which is encountered in daily living, the unit for temperature, degree Celsius (pronounced sell-see-us). Most adults are surprised to learn that "degree Centigrade," which they vaguely remember from their school days, has been changed to "degree Celsius."

The change came about in 1948, at the General Conference on Weights and Measures which convenes periodically to review and ratify measurement standards. A debate arose concerning the name of a unit for metric temperature. Some conferees favored the English "degree Centigrade," and others favored the French "degré centisimal". By coincidence, the centigrade scale had been invented by Anders Celsius. Since his last name started with "C," his name was selected as a compromise.

The Celsius scale is simpler than the Fahrenheit scale. The drawing below illustrates its simplicity. Water boils at 100°C and freezes at 0°C. If you can remember the four temperatures shown on the thermometer, you'll have a good beginning on making sense of the Celsius scale.



LESSON 6: MASS (WEIGHT?)

The purpose of this lesson is to explain the difference between mass and weight. The kilogram is the unit of mass, and the Newton (after Sir Isaac Newton) is the unit of weight.

If you were an astronaut in outer space, the objects in your space craft would have very little weight. If you held a bowling ball in your hand and released it, it wouldn't fall. It would remain suspended in space. If the bowling ball were placed on a scale, it would read zero. It would be weightless. Why? Because the bowling ball is so far from the earth that it has escaped the pull of the earth's gravity.

Weight, then, is a measure of gravitational pull on an object. The weight of an object can vary, depending on where it is in the universe.

The mass of an object never varies. It is the same on earth as anywhere else in the universe. Mass is a measure of how much matter an object contains. The bowling ball is weightless in space, but it still has the same mass. Because of its mass, if you kicked it with your bare foot it would still hurt, whether you were on earth or in a spaceship.

We determine the weight of an object by spring scales which measure the downward pull on an object placed on it. This downward force is measured in Newtons. The mass of an object, on the other hand, is determined by using a balance: the object is placed on one side and balanced with standardized mass pieces. This is what a pharmacist does when he mixes a compound.

However, the mass of an object is directly proportional to its weight on earth. That is, a one-kilogram mass has a weight of about 9.8 Newtons at sea level; a two-kilogram mass has a weight of about 19.6 Newtons; etc. Thus, either mass or weight gives us a good measure of how much matter an object contains. Therefore, in everyday usage spring scales are used for determining mass in kilograms because it is much more convenient than using a balance. The 4M COMPANY uses the words interchangeably - mass (weight). For everyday usage, the distinction is unimportant.

LESSON 7: SI

The French scientists made several errors in their original calculations. For example, they miscalculated the distance from the equator to the north pole by about 2000 meters, and instead of being equal to one cubic decimeter, the liter was actually equal to 1.000028 cubic decimeters.

To correct these errors, various scientific organizations of the world met in 1960 to devise a modern metric system which is called the International System of Units (or SI for short, after the French Le Systéme Internationale d'Unités). SI was created to meet the exacting demands for precise scientific measurement. Most of the units and prefixes will not be used by the average citizen. But for the sake of completeness, we include a list of the base units and all the prefixes.

BASE UNITS

Quantity	Name	Symbol
length	meter	m
mass	kilogram	kg
time	second	s
electric current	ampere	A
thermodynamic temperature	kelvin	K
amount of substance	mole	mol
luminous intensity	candela	cd

Two units not on the list above are commonly used with the metric system. Instead of referring to liquid capacity in terms of cubic decimeters, the liter is used. And instead of using the Kelvin for temperature, degree Celsius is used (the Kelvin scale was derived from the Celsius scale).

PREFIXES

Prefix	Symbol	Pronunciation Symbol	Multiples & Fractions
exa	E	ex´ah	1 000 000 000 000 000 000
peta	P	pet´ah	1 000 000 000 000 000
tera	T	tear´ah	1 000 000 000 000
giga	G	jī´g,ah	1 000 000 000
mega	M	meg´ah	1 000 000
kilo	k	kill´oh	1 000
hecto	h	heck´toh	100
deka	da	deck´ah	10
deci	d	dess´ih	0.1
centi	c	cent´ih	0.01
milli	m	mill´ih	0.001
micro	μ	mike´roh	0.000 001
nano	n	nan´oh	0.000 000 001
pico	p	pee´koh	0.000 000 000 001
femto	f	fem´toh	0.000 000 000 000 001
atto	a	att´oh	0.000 000 000 000 000 001

Complete these equations if you can:

1 000 000 lomania = _____

1 000 000 000 ntic = _____

0.000 001 nesia = _____

1 000 000 000 000 tory = _____

0.000 000 000 000 000 001 rney = _____

1 000 000 000 000 000 000 rcist = _____

LESSON 8: SI STYLE CONVENTIONS

Think of it! There is no universal language, there is no universal monetary system. But at last we stand on the threshold of having a universal measurement system, a system understood by people all over the world. To make communication easier, certain style conventions are recommended. This section cites the major conventions.

1. Use a space to separate large numbers into groups of three. Do not use a comma. In many countries a comma is recognized as a decimal point.

Example:	Correct	Incorrect
	600 300.6	600,300.6

2. Use a zero in front of the decimal point when the numerical value is a partial unit.

Example:	Correct	Incorrect
	0.6 mm	.5 mm

3. Use a decimal to express partial units. Avoid using fractions to express partial units.

Example:	Correct	Incorrect
	0.25 kg	1/4 kg

4. Use uppercase or lowercase letters as they are given in the table. All abbreviations or symbols are to be used in the singular form. Do not use periods after symbols unless they conclude a sentence.

Example:	Correct	Incorrect
	mm (millimeters)	mms or mm's
	cg	c.g.
	ℓ	ℓ.

5. Prefixes must be combined with units. In common usage "kilo" means kilogram. Such usage is not preferred.

6. Avoid mixing units.

Example:	Correct	Incorrect
	12.75 m	12 m 75 cm

7. Avoid using multiple prefixes.

Example:	Correct	Incorrect
	ps (picosecond)	μμs (micromicrosecond)

8. Avoid capitalization of unit names (except Celsius) unless they start a sentence. Listings should be lowercase.

Example: Correct - The base unit for mass is the kilogram.

Incorrect - The base unit for mass is the Kilogram.

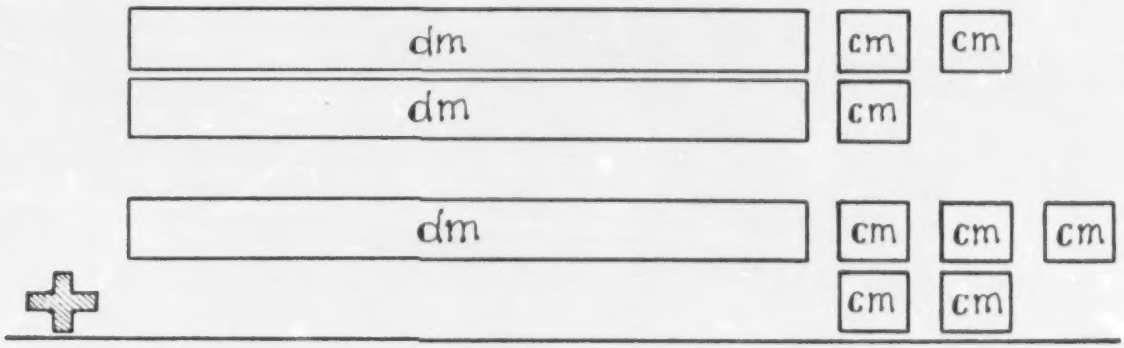
NEXT-TO-LAST-LESSON: DECIMALS

Our number system, our monetary system, and the metric system all share a common characteristic: they are decimal in nature. Because of this, the switch to metric makes the study of decimals even more important than ever. The 4M COMPANY begins the study of decimals in the third grade. The purpose of this lesson is to illustrate how the decimal nature of the metric system is used to teach decimals.

Since a decimeter is one-tenth of a meter, decimeters are used to introduce tenths. Students make a meter strip marked in tenths of meters and use it to measure various lengths.

Similarly, since a centimeter is one-hundredth of a meter, centimeters are used to introduce hundredths. And a millimeter, being one-thousandth of a meter, is used to introduce thousandths.

Addition and subtraction of decimals are explained in terms of metric units. Thus, the problem $\begin{array}{r} 0.23\ \text{m} \\ +0.15\ \text{m} \\ \hline \end{array}$ is represented as follows:



If placed end-to-end, these units would come to the 0.38 m mark on a meter marked in hundredths. Since 10 centimeters can be exchanged for 1 decimeter, borrowing and carrying are easily explained in terms of metric units. The students soon see that adding and subtracting decimals is very similar to adding and subtracting whole numbers.

LAST LESSON: METRIC FOR EVERYDAY LIVING

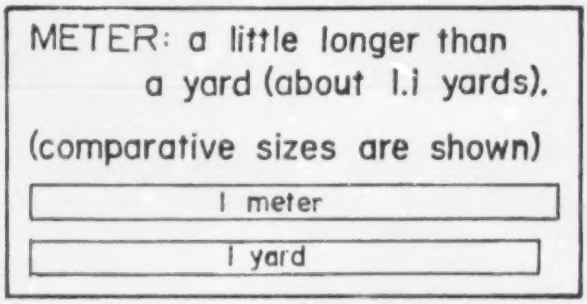
In this section we list those metric units which are most commonly used in everyday living.

Length: 1) A meter is a little longer than a yard.

2) A kilometer (1000 meters) is about 6/10th of a mile.

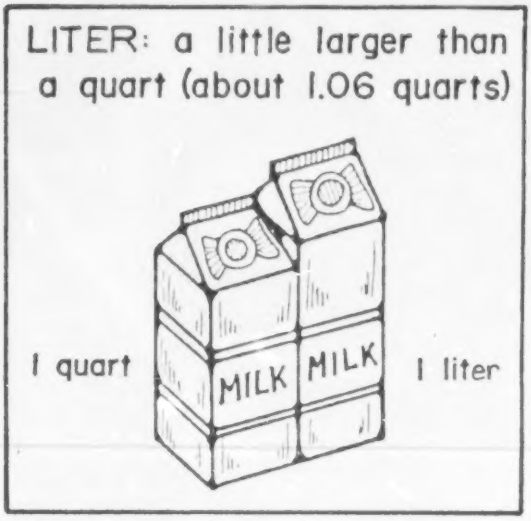
3) A centimeter (0.01 meter) is about the width of a paper clip.

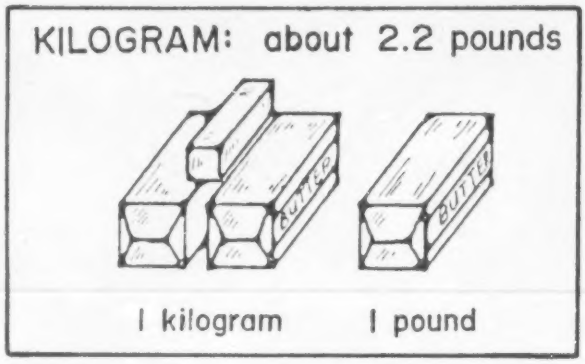
4) A millimeter (0.001 meter) is about the thickness of a dime.



Capacity: 1) A liter is a little larger than a quart (about 1.06 quarts).

2) A milliliter is 1/5th of a teaspoon.





Mass: 1) A gram is the mass of two small thumb tacks.

2) A kilogram is about 2.2 pounds.

3) A metric ton is 2200 pounds.

4) A milligram is the weight of a bee's wing.

ANSWERS TO PROBLEMS

LESSON 3:

hectogram	deciliter
dekaliter	centiliter
kilometer	decigram
milligram	dekagram
hectoliter	dekacards
centigram	deciArnaz
millimeter	centimentalist
centimeter	kilomanjaros
milliliter	millitary
hectoliter	decimate
kiloliter	kilowhats?
kilogram	milliscent
dekameter	centipede
decimeter	

LESSON 7:

megalomania
jigantic
micronesia
teratory
attorney
exarcist